NEWS BULLETIN

No.....

CONTENTS

.s that soul was whose progeny they are; nay they do preserve as in a
arest efficacy and extraction of that living intellect that bred them.

—*John Milton*

Prof. RAMESHWAR SHARMA
Principal & Controller

CHUTETA
r

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Officer-in-charge Library

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Librarian

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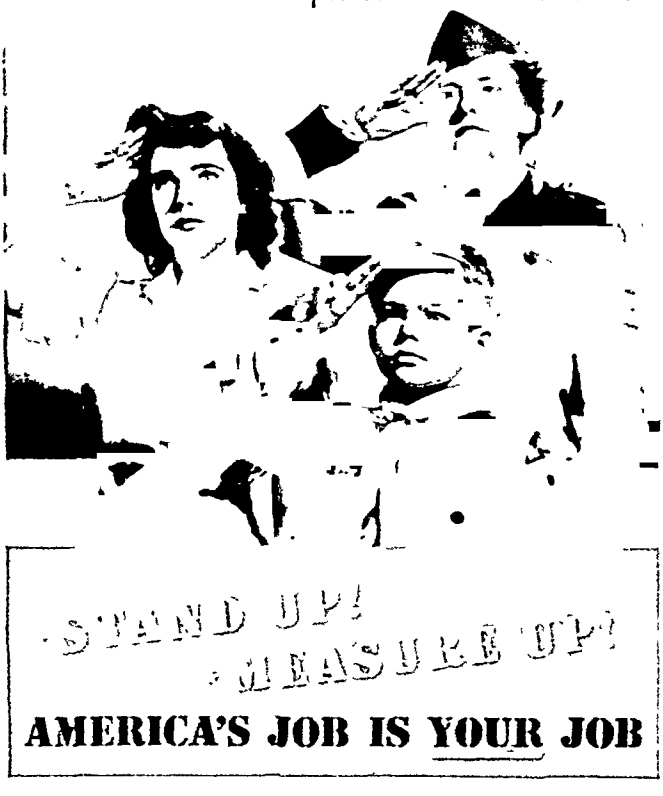
G. L. SAINI
Asstt. Librarian

One of several inspiring posters in color, which will be used as a theme for patriotic displays during National Posture Week.



★
★
★

May 1st to 6th

CAMP

6th Annual

NATIONAL POSTURE WEEK

The annual observance of National Posture Week has done much to focus nation-wide attention on the significance of good posture and has encouraged many suffering from poor body mechanics to seek professional counsel.

The importance of good posture to good health and physical fitness will again be emphasized through the distribution of ethical and authoritative literature to schools, colleges, industrial and professional public health educational groups. Large numbers of physicians, educators and groups in the field of public health have expressed their appreciation for this work.

It is our hope that our current campaign and efforts will continue to merit this approval and contribute further to America's victory program for physical fitness and for the arduous post-war readjustment period which is anticipated.

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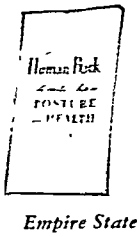

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FOR BETTER POSTURE

Empire State Building, New York 1, N. Y. • (Founded by S. H. Camp and Company, Jackson, Mich.)

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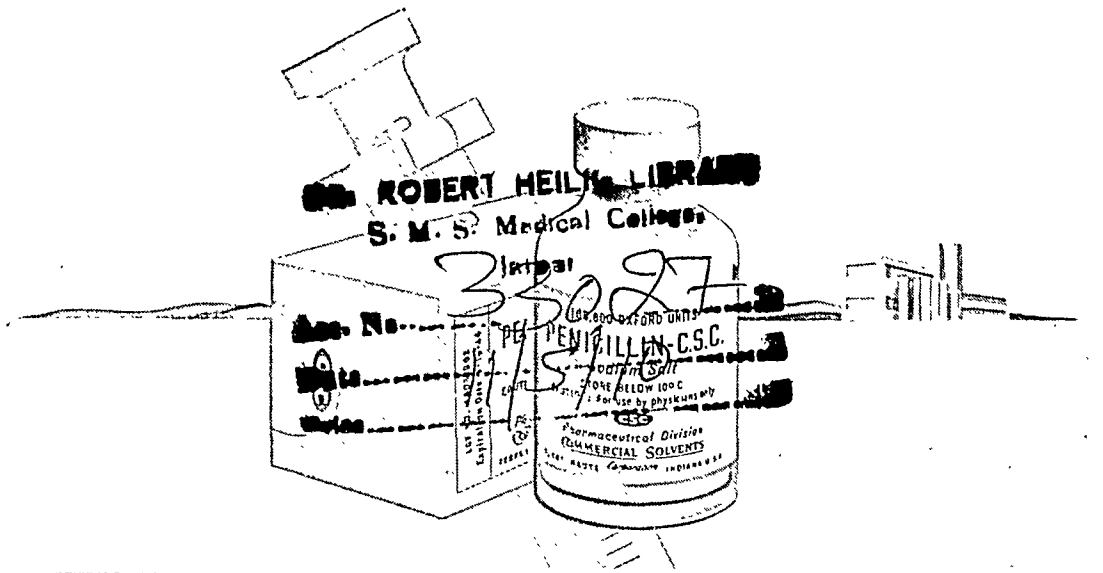


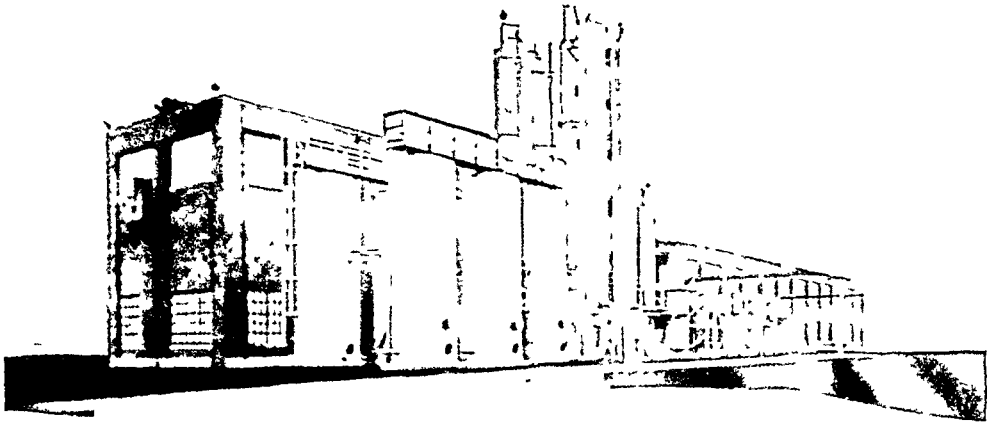
and its Quarter-Century Background

Ehrlich's prophetic vision of the "magic bullet" which would combine deadly efficacy against pathogenic bacteria with perfect compatibility in the human organism, approaches fulfillment in penicillin. Contrary to Ehrlich's expectation, this magic bullet is not a synthetic drug developed by a chemist—it results from the metabolism of a mold. Biologic production of a chemotherapeutic agent thus is now applied in the pharmaceutical field, presenting a new approach.

Instead of the pure rationale of chemical formulas, the life habits of a microorganism are the controlling factor in the manufacture of penicillin; the chemist's important function here consists of guarding his microbian "workmen" and leading them to maximal production.

It is this type of work in which Commercial Solvents Corporation has been engaged since its beginning. For a quarter century, the life habits of bacteria and molds have been the study to which an ever increasing number of scientists in the C. S. C. Research Laboratories are devoting their lives. From their studies have come valuable products, such as butanol, acetone, vitamins, etc., achieved by exacting standards of sterility, an extremely important factor in the working of the highly sensitive microorganisms. What other manufacturer of any kind in the United States has had comparable experience in the application of microbiologic methods to mass production?

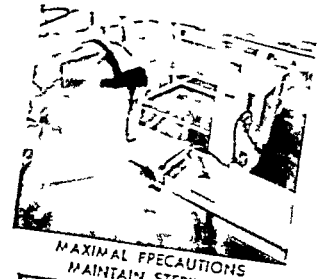
With the confidence born of this experience Commercial Solvents Corporation built, with its own funds, what now may well be the largest penicillin plant in the United States. It incorporates not only the fruits of 25 years of experience, but also the latest developments in the testing, handling, and packaging of a product upon the integrity of which the physician so often may have to stake his patients' lives. Rigid laboratory con-



trols assure for Penicillin-C. S. C. uniform potency, sterility, and freedom from pyrogens.

Thus Commercial Solvents Corporation brings to the manufacture of penicillin not only outstanding production facilities, but also the knowledge born of a quarter century of research and actual scientific operating experience, in a field not only difficult but largely unexplored by the pharmaceutical industry in general.

The capacity of the C. S. C. penicillin plant is conservatively rated at 40,000,000,000 (forty billion) Oxford Units per month. But for the time being its entire production must go to our armed forces. When their needs are met, Penicillin-C. S. C. will be available for civilian medical practice, not only in adequate distribution throughout the United States, but also at the reasonable cost to the patient which is every physician's desire, and which is made possible by C. S. C. volume production.



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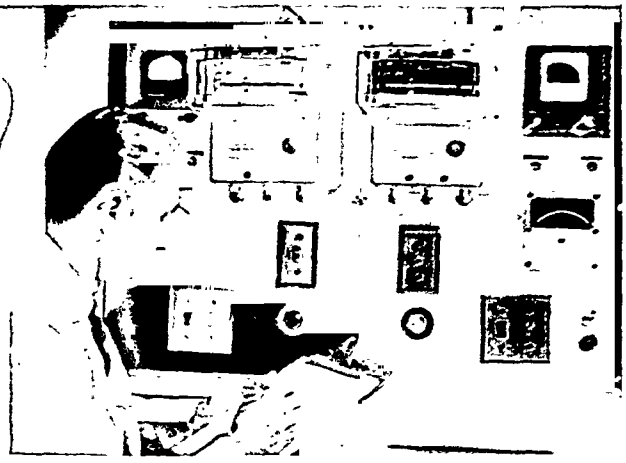
		PRESCRIPTION PRICES Old	New
ERTRON	50 capsules	$ 4.50	$ 3.50
ERTRON	100 capsules	8.00	6.00
ERTRON	500 capsules	35.00	25.00

The price of ERTRON Parenteral is unchanged —$5.00 per package of six—1 cc. ampules.

REDUCED



Control panel of special Whittier electrical activation unit.

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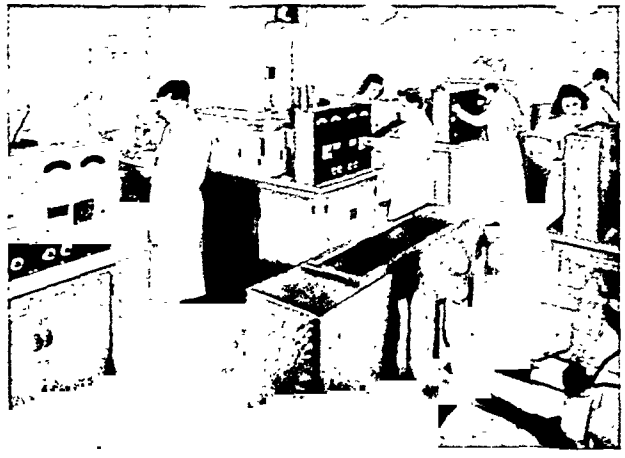
The exclusive Whittier Process assures high potency and absence of deleterious by-products. Careful laboratory control and assay guarantee the safety and effectiveness of ERTRON.



Battery of Whittier activation units producing ERTRON.

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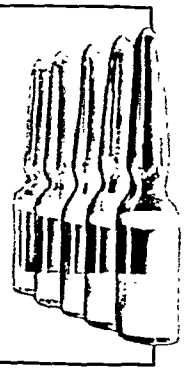
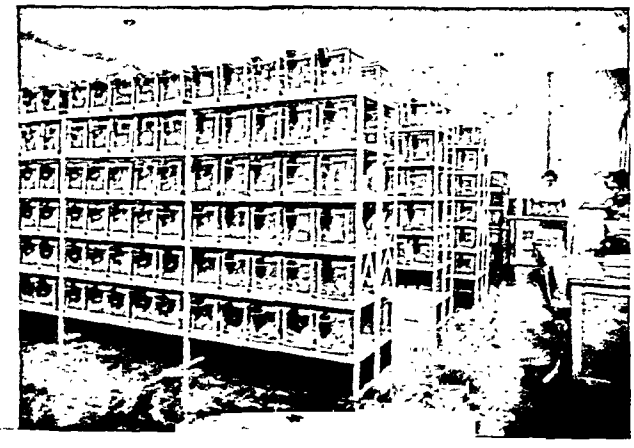
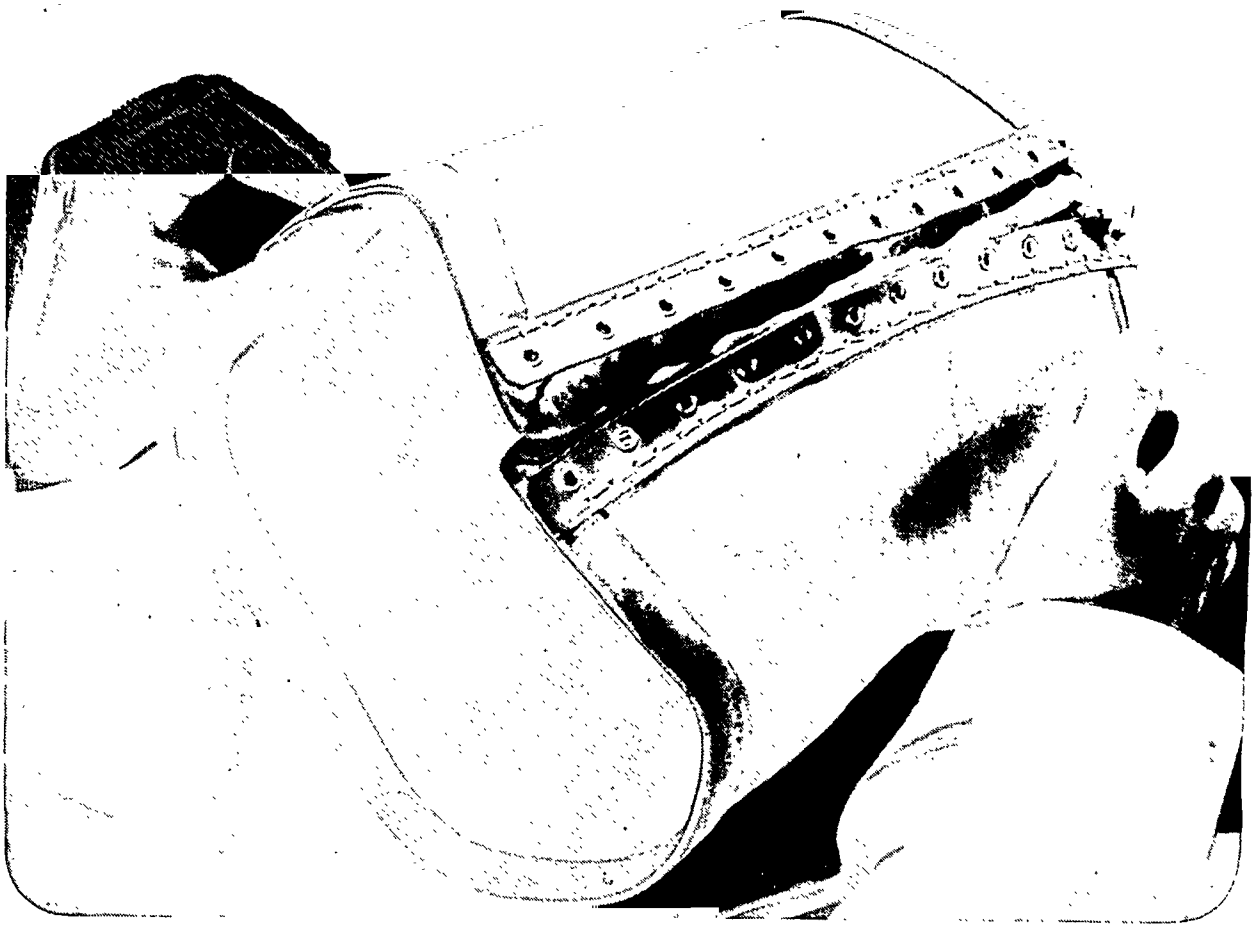




*Reg. U. S. Pat. Off.



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No matter how complex your next cast problem may be (or how simple) you'll find Castex Rigid Bandage the ideal cast material. Try it.

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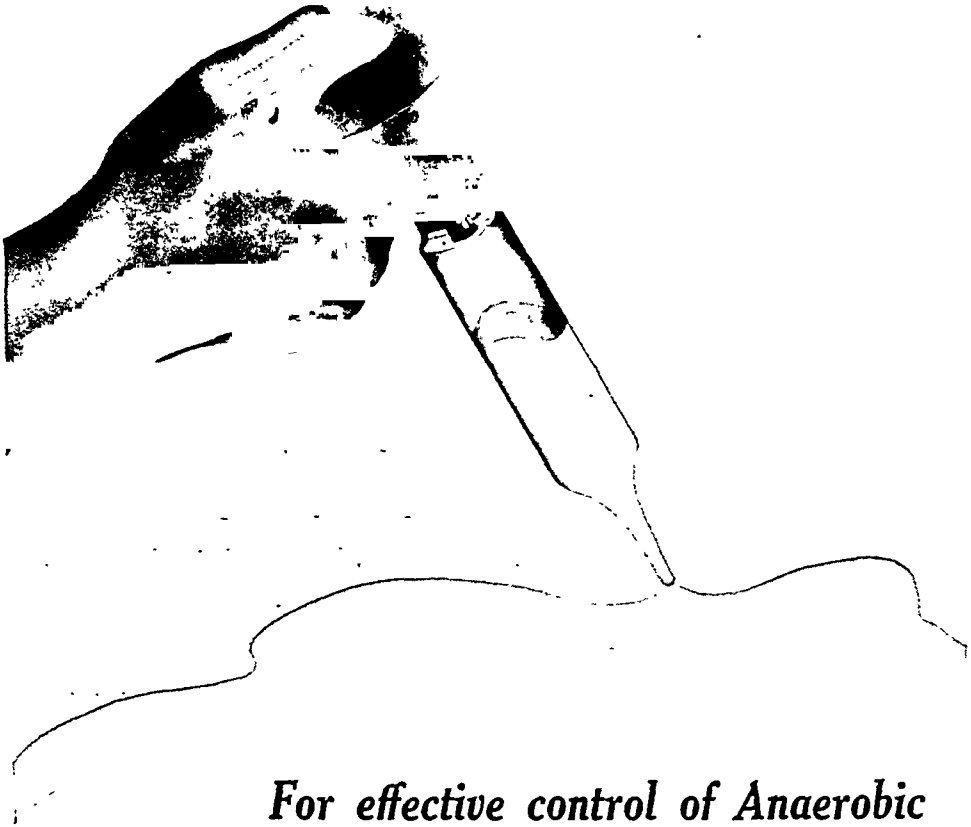

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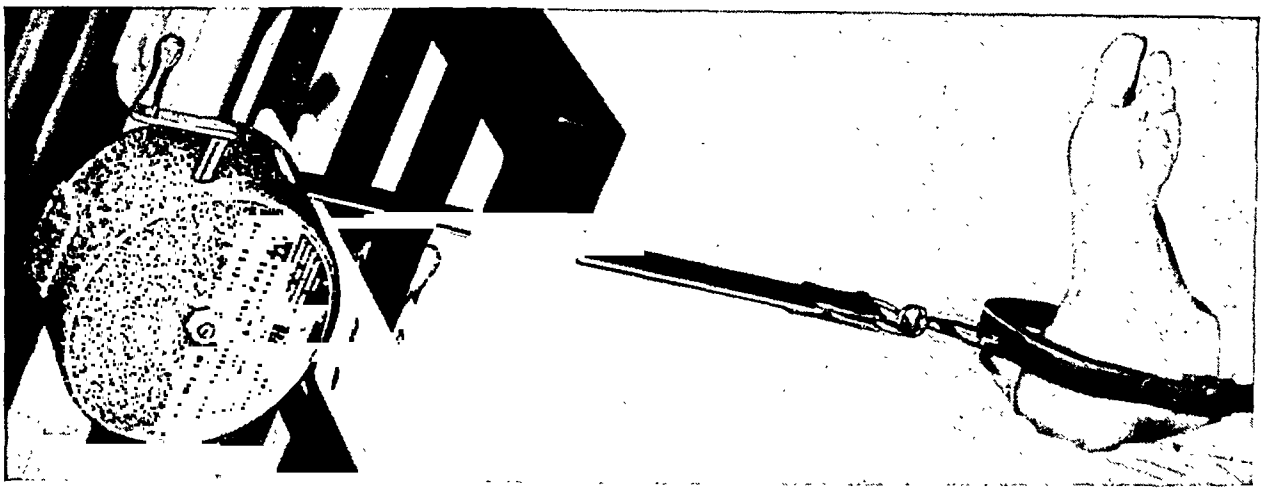

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This new power-spring traction apparatus can be used for all types of traction where pulleys and weights are now used. This includes skin or pin traction, skull traction, overhead traction from a frame, as well as counter traction. A removable key adjusts the traction to up to twenty pounds. A scale shows the number of pounds used. The apparatus is easily attached to any position on the bed, using only the attachments supplied.

NOTE: The elimination of swinging weights makes this apparatus ideal for use on board ship, train, plane, or in a car.

No. B-1000 Herzmark-Adams Traction Reel, complete with two 12″ horizontal bars and one 14″ vertical extension bar.....**Each $34.50**

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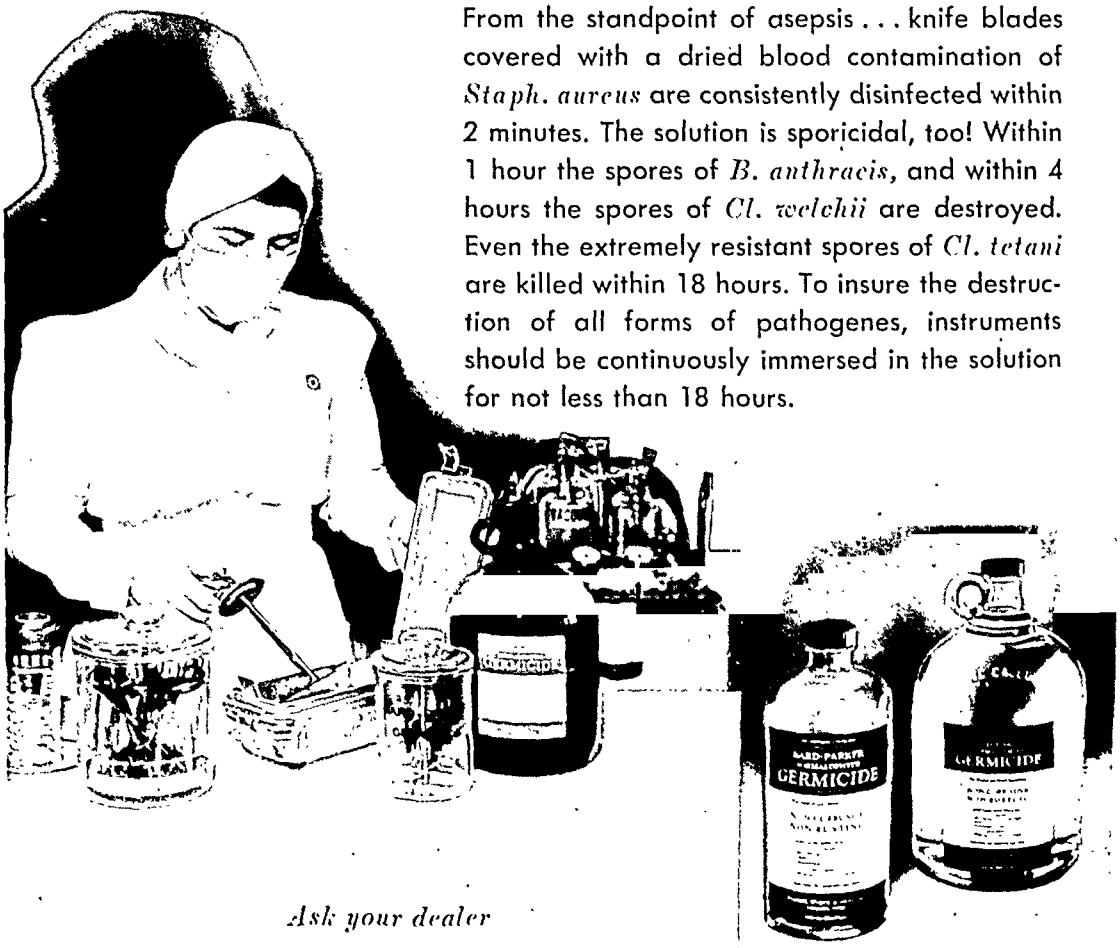
From the standpoint of asepsis . . . knife blades covered with a dried blood contamination of *Staph. aureus* are consistently disinfected within 2 minutes. The solution is sporicidal, too! Within 1 hour the spores of *B. anthracis*, and within 4 hours the spores of *Cl. welchii* are destroyed. Even the extremely resistant spores of *Cl. tetani* are killed within 18 hours. To insure the destruction of all forms of pathogenes, instruments should be continuously immersed in the solution for not less than 18 hours.



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With Lipiodol, soft tissue changes become readily visible to the roentgen ray. The location and extent of sinus and fistula tracts are accurately recorded on the film when this contrast medium is installed into such lesions. Thus accurate diagnosis is made possible, greatly broadening the physician's ability to detect and identify pathologic aberrations. Lipiodol (Lafay) contains 40 per cent iodine in firm chemical union with poppyseed oil. Its high iodine content renders it more than amply radiopaque to contrast with such dense structures as bone. Note the bold delineation of the globule of Lipiodol overlying the bone in the roentgenogram reproduced above. Lipiodol is also widely employed in the localization of bronchial and pulmonary lesions, for diagnosis and localization of spinal cord compression and tumors, and as an aid in detecting mucous membrane thickening and tumors of the paranasal sinuses. In gynecology, Lipiodol facilitates localization of pelvic neoplasms and displacements, and establishes obstructions in the fallopian tubes.

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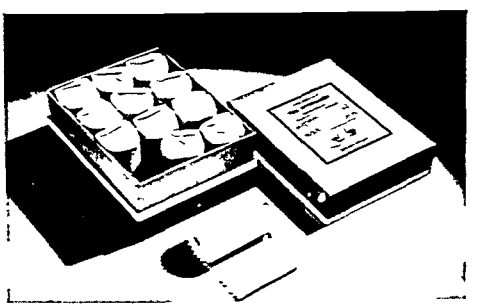
THE ORIGINAL IODIZED OIL

STRENGTH without weight

● "Specialist" plaster-of-Paris bandages and splints are frequently used together to build a strong, durable cast of minimal weight. By reinforcing areas with a plaster slab made with six or more "Specialist" splints, at right angles to a light, circular body cast, sound medical engineering principles are utilized. A final circular covering then completes the cast. Reduction of bulk and weight affords added patient comfort. Time, labor and material are conserved.

"Specialist" bandages and splints are hard-coated, non-dusting, quick-saturating—ideally suited to this technique.



"SPECIALIST" BANDAGES
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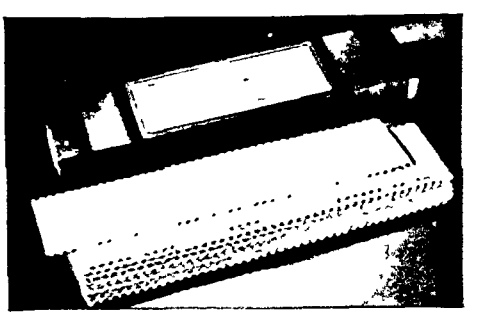
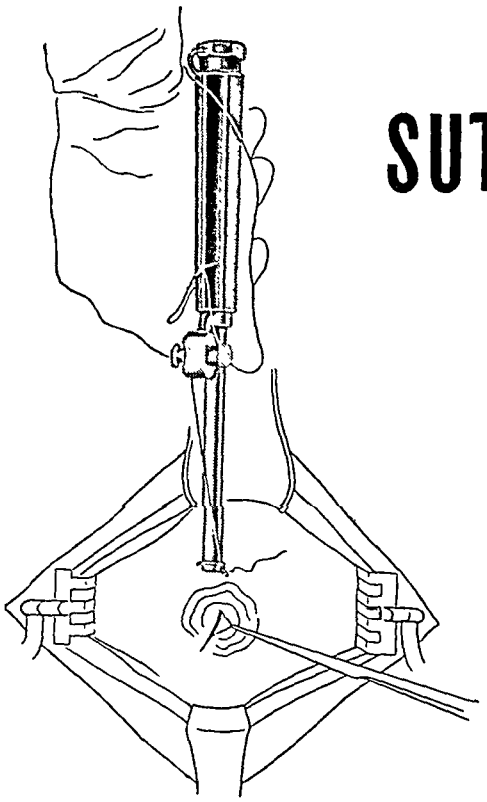
BANDAGES and SPLINTS



"SPECIALIST" SPLINTS



BETTER SUTURING CONTROL

WITH THE SINGER SURGICAL STITCHING INSTRUMENT

The new Singer Surgical Stitching Instrument enables the surgeon to enjoy a far closer and more certain control of both needle and suturing material.

It obviates the danger of a needle slipping from its holder because of too loose clamping . . . or breaking off because of too tight clamping. The Singer needle locks *positively* in its handle with predetermined tension—yet may be loosened by a simple turn of the handle lock nut, for adjustment and relocking at any of the various useful angles.

The suture material, too, remains more safely under the operator's command. Since the instrument releases it only as needed, and since stitch formation employs only the end of the suture material directly at the needle, *there are no long loose ends to break the aseptic technic by becoming contaminated through contact with infectious material.*

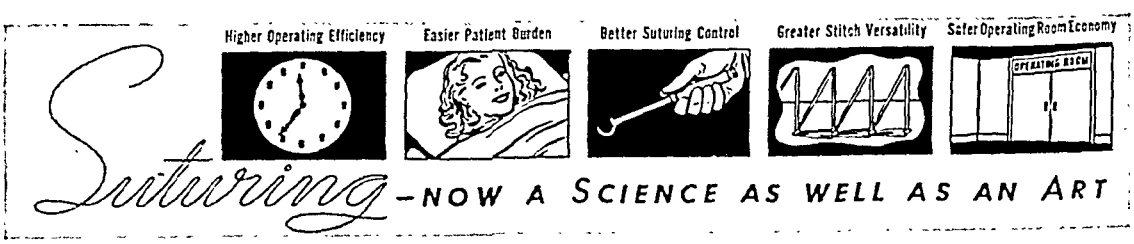
These are but two of the factors that contribute to the high suturing efficiency attainable with this fine surgical instrument—in either a deep or superficial field. Any standard suture material may be employed, or any of a wide variety of available needle sizes, shapes or styles.

The instrument may be sterilized as a complete unit, and can be readily taken apart for cleaning and quickly reassembled. All parts are rust-resistant.

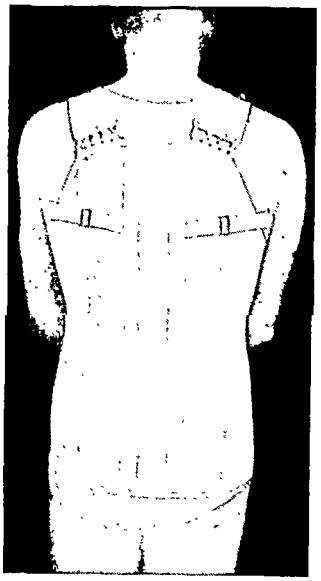
Illustrated booklet. Write Dept. X-4
Motion pictures demonstrating operative technique also available for group meetings.

SINGER SEWING MACHINE COMPANY, *Surgical Stitching Instrument Division*, 149 BROADWAY, NEW YORK 6, N. Y.

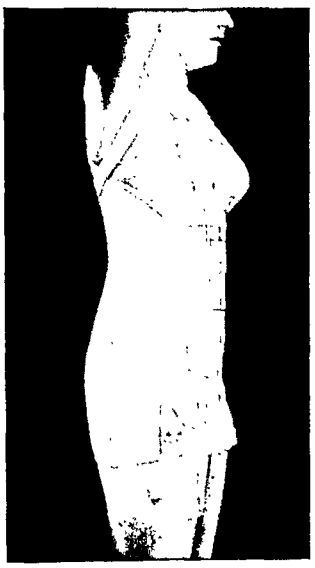
Personal demonstration available at your local Singer Shop



Orthopedists are finding
SPENCER SPINAL SUPPORTS
Notably Effective



Spencer Spinal Support designed for male patient. Rigidity provided when required.



Spencer Spinal Support designed for female patient. Any degree of firmness desired. Spencer Supports are also designed for children.

Rigid support provided when desired, as aid to treatment and after cast removal. Degree of firmness governed by the doctor. Useful in treatment of:

Intervertebral Disc Extrusion

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Poliomyelitis

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Osteoporosis

. . . and other back conditions

Each Spencer Support is individually designed, cut and made for each patient to restore balance, inhibit movement of affected part (when desired), support abdomen, bind pelvic girdle snugly.

The doctor tells us what he wants—we assume all responsibility for proper design, fit and patient's *permanent* satisfaction.

Many orthopedists have expressed pleasure that the *rigidity* they required for certain cases was accurately met by a support of cloth with spaced steels. Spencer Spinal Supports that are rigid, yet light-weight and comfortable, are often used instead of a brace.

For service at patient's home, your office or hospital, look in telephone book under "Spencer Corsetiere"—or write direct to us.

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The Journal of Bone and Joint Surgery*

The Official Publication of
The American Orthopaedic Association
The British Orthopaedic Association
The American Academy of Orthopaedic Surgeons
Owned and published by The American Orthopaedic Association
*Title registered in United States Patent Office

VOL. XXVI, No. 2 *April, 1944* Old Series VOL. XLII, No. 2

Published quarterly January, April, July, and October
8 THE FENWAY, BOSTON, MASSACHUSETTS

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VOL. XXVI, NO. 2 APRIL, 1944 Old Series Vol. XLII, No. 2

The Journal of Bone and Joint Surgery

FIBULAR SUBSTITUTION FOR TIBIAL DEFECTS *

BY ARTHUR G. DAVIS, M.D., ERIE, PENNSYLVANIA

The following is offered as a preliminary report on a method which holds forth some promise in non-unions of the tibia, where ordinary bone-graft methods seem inadequate. The cases in evidence are few in number, but because of the need for remedies for bone defects induced by war, the mention of this technique seems justifiable at this time. Many methods of using the fibula have been described in the past. In 1939, Milch described a similar technique.

Six cases are presented, two occurring in children, and four in adults. Each case presents a problem involving the alternative of amputation or bone-grafting by other than ordinary methods. Two cases were frankly osteomyelitic; two, infected compound wounds; one, typical pseudarthrosis following fracture in a child; and, one pseudarthrosis following a plated compound fracture in an adult. All attained union, though one patient had an amputation several years later.

The method consists of a one-step substitution or reinforcement of the defective tibia with the fibula, with or without the addition of a sliding or inlay graft. The result is a fusion between the fibula, the remains of the tibial fragments, and the interposed graft. All elements are fused into a single weight-bearing column.

TECHNIQUE

1. A roentgenographic templet is prepared and an appropriate level of fibular section is determined.

2. A full-length incision is made, exposing the entire fibula from head to malleolus.

3. A nearly full-length incision of the fibula is made with a bone saw. This incision follows roughly the anterior crest.

4. The soft parts, muscles, nerves, and vessels of the anterior tibial compartment are dissected off the anterior side of the interosseous membrane, and the outer aspect of the tibia or its remaining fragments are thus exposed.

5. The fibular fragments are pushed across the space and apposed to the denuded tibial fragments. After this trial fit, suitable channels are gouged to receive the fibular fragments.

6. If, as is usual, an additional sliding, onlay, or wedge graft is contemplated, the procedure is executed at this point through an incision over the anteromedial surface of the tibia.

* Read at the Annual Meeting of The American Academy of Orthopaedic Surgeons, Chicago, Illinois, January 25, 1944.

7. Vitallium screws are then used to transfix the tibia, fibula, and wedge graft, forming a continuous bone mass.

8. Where possible, the reflected anterior and posterior periosteal flaps from the tibia and fibula, respectively, are made to contact each other, thus forming a continuous tube enveloping the involved area.

9. The irregular spaces left between the sides of the two bones are filled with bone chips.

10. A dressing of the "diminishing-pressure-cone" type[1] is applied with a woven elastic bandage from toes to knee.

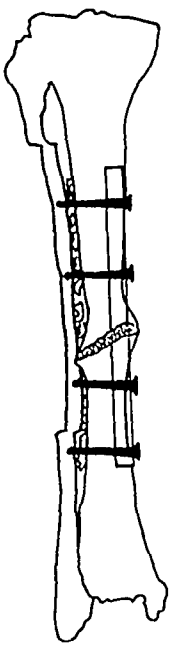

FIG 1-A

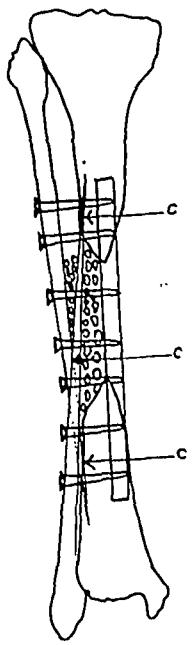

FIG 1-B

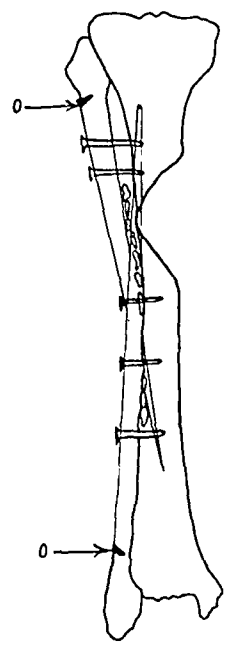

FIG. 1-C

Fig. 1-A: Fibula position convenient for use as one component of dual graft (See Figs. 5-A to 5-D).

Fig. 1-B: Typical use of fibula as two long fragments with graft from opposite tibia and small bone fragments between. Note at *C* the several areas of callus formation thus created (See Cases 1 and 5, and Figs. 4-A to 4-E).

Fig. 1-C: Use of fibula as two long fragments closely applied to tibia, avoiding defective area. Note at *O* points of partial osteotomy to gain greater side-to-side approximation (See Case 4).

CASE REPORTS

CASE 1. R. F. (Hamot Hospital No. 48330), aged eight, had osteomyelitis of the tibia. About two-thirds of the tibial shaft had sequestrated and was removed, leaving a complete defect of the tibia of about four to five inches. An operation was performed on May 21, 1928; a large graft from the opposite tibia was placed between the tibial fragments, and the fibula was sectioned as described in Figure 1-B. The patient ran a septic course afterward, with a temperature running to 102 degrees; she was treated with Carrel-Dakin solution. In August 1928, a sequestrectomy was done. An additional sequestrectomy was done in August 1929, and the wound then ceased draining. The girl was seen for about five years afterward regularly at clinics and had a good functioning leg with a slight outward bowing. The patient cannot be traced at the present time, and the roentgenograms have been destroyed by the Hospital.

CASE 2. J. H. (Hamot Hospital No. 68944), aged thirteen, was operated upon in February 1931 for a pseudarthrosis resulting from a fracture. A Böhler drilling of the bone ends was done with no success. In November 1931, an operation of the type shown in Figure 1-B was performed. The area of the false joint was removed, the bone ends were drilled, and a greenstick longitudinal fracture of the fibula was produced, and the ends were imbedded in the opposite ends of the fractured tibia. The fragments of both bones were united with two vanadium screws. On April 29, 1932, the screws were removed. The patient at the present time is a taxicab driver. Figure 2 indicates the present condition of his leg bones. The roentgenograms of 1931 have been destroyed by the Hospital.

CASE 3. Mrs. M. W. (Hamot Hospital No. 87554), aged forty-five, was a luetic with a four plus Wassermann. She had sustained a pathological fracture of the lower third of the tibia. On October 21, 1934, a massive graft five inches long was applied, but this failed to unite. On November 11, 1935, the combination of a massive graft and the fibular transplant as illustrated in Figure 1-B was done. Union sufficient for weight-bearing with protection occurred by February 1936. The union continued intact until 1940, when there was a recurrence of the local pathological condition which caused warping of the grafted area, and an amputation was done in 1942. The roentgenograms have been destroyed by the Hospital.

CASE 4. E. J. (Hamot Hospital No. 30908), aged forty, was admitted to Hamot Hospital two days after sustaining a compound fracture of the leg involving both bones. The compound wound was treated with sulfonamides, and a secondary closure was done after seven days (Fig. 3-A). Twelve days later the comminuted fracture was plated. Four months later a flare-up in the region of the fracture required the removal of the plate and screws. Ten months after injury an osteotomy of the tibia had to be done to remove sequestra. Thirteen months after the accident there was still no union and drainage persisted in an area

toward the upper inner aspect of the tibia. In order to avoid this infected area, a fibular transference only was done (Figs. 1-C and 3-C). The patient was ambulatory in a Delbet cast four months later. A month later, the patient refractured the tibial portion, but the fibular union remained intact (Figs. 3-D and 3-E). In November 1943, two screws and granuloma surrounding the screws were removed, and the patient is now comfortably ambulatory without support.

CASE 5. J. J. (Hamot Hospital No. 33445), aged twenty-eight years, sustained multiple fractures in October 1941, including traumatic amputation of the left arm, fracture of the right tibia, and compound fracture of the left tibia and fibula. He was admitted with a non-union of the left leg in May 1942. When first seen, two months prior to admission, the right leg was ununited. At the time of admission, seven months after fracture, union had occurred in this leg. A typical sliding bone graft applied to the left tibia was combined with a heel-cord lengthening. The patient was ambulatory in three months without support. Four months later he fell and refractured the left tibia. In October 1942, a dual-graft operation was performed, using the fibula and a massive graft; the original graft was removed. He was again ambulatory and returned to work for several months. In October 1943, he was readmitted to the Hospital with considerable swelling, heat, and induration around the fracture site. While being prepared for operation, he fell out of bed and refractured this tibia, following which all of the screws and granuloma surrounding the screws were removed. On December 15, 1943, the patient was again ambulatory. On February 15, 1944, roentgenograms showed firm union, but he was still wearing a plaster shin guard.

From the point of view of the fibular-tibial dual graft, this must be considered as a failure, because of a low-grade infection combined with probable electrolytic action around the screws.

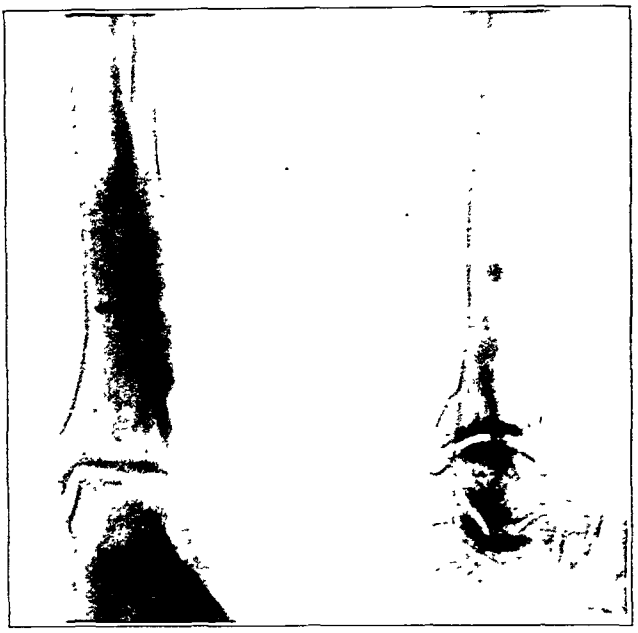

FIG. 2

Case 2. Result twelve years following operative technique as depicted in Figure 1-B.

CASE 6. A. Z. (Hamot Hospital No. 44920), aged fifty-six years, had a typical case of pseudarthrosis following plating of a compound fracture of the tibia. The fracture had occurred in May 1941. The patient was admitted to the author's Service in April 1943, with a non-union (Fig. 5-A). A typical dual-graft operation, using the fibula as one side and a large sliding graft as the other component, was performed in July 1943. Three months later, there was considerable rarefaction around several of the screws, and it was feared that this might lead to a refracture. The screws and granuloma were, therefore, removed (Fig. 5-C). On December 15, 1943, the patient was ambulatory without support other than a plaster shin guard. On March 1, 1944, the patient had been ambulatory without support, and had had strong structural callus for two and one-half months.

COMMENTS

Defects such as are shown in Figure 1-C and Case 4, require simply the apposition of the fibular and tibial fragments, care being exercised to avoid all contacts with the open sinus tract by screws, dissection, drill holes, periosteal reflection, or otherwise. The aim in such cases is simply a synostosis.

Defects such as are seen in Figure 1-A and Case 6, do not require longitudinal sectioning of the fibula. In this case the complete circumference of the fibula acts as one component of a dual graft.

Using the fibula in this manner helps to absorb strain in the vertical direction as well as acting as a guard against horizontal and angular stresses. In non-unions which have failed

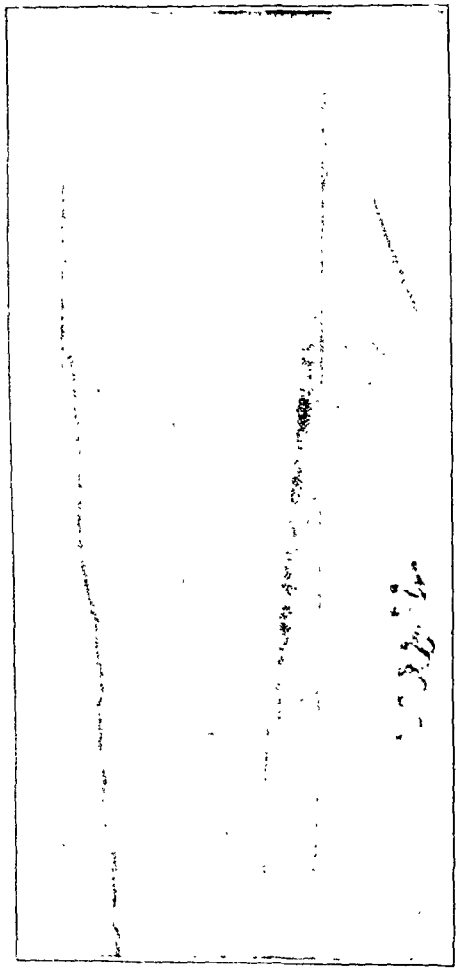

FIG. 3-A

Case 4. Compound fracture.

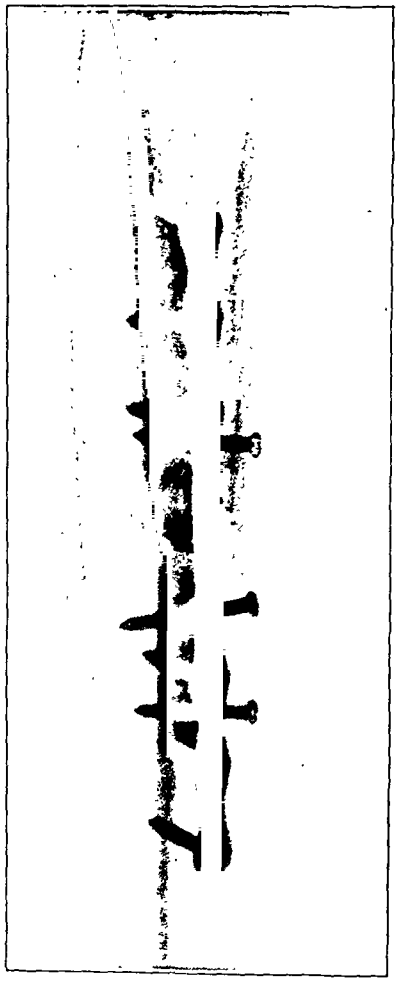

FIG. 3-B

Nineteen days later, showing plating of the comminuted fracture after the compound wound had been treated with sulfonamides and a secondary closure had been done.

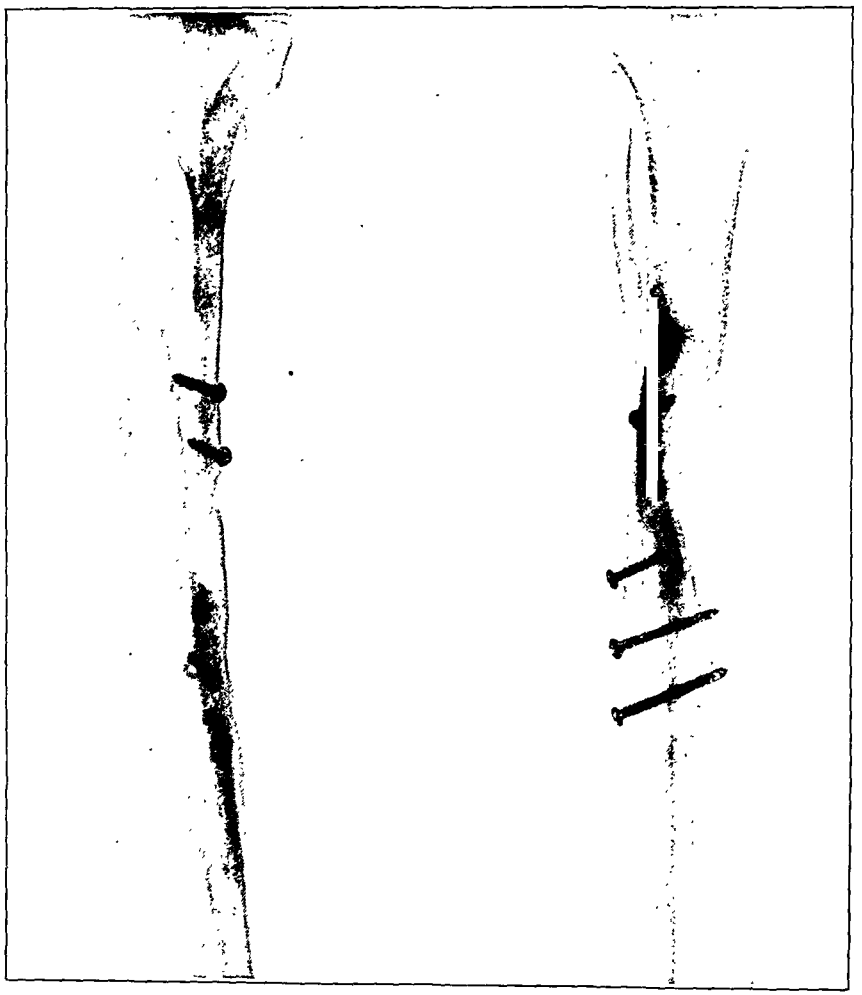

FIG. 3-C

Ten months later, after drainage lasting several months, showing fibular transference according to the method depicted in Figure 1-C.

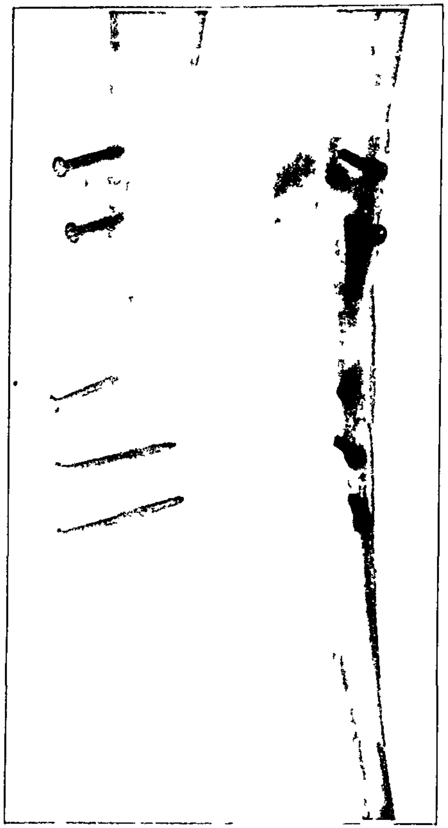

FIG. 3-D

Showing rarefaction around a screw and refracture of the tibia. The fibular union remained intact.

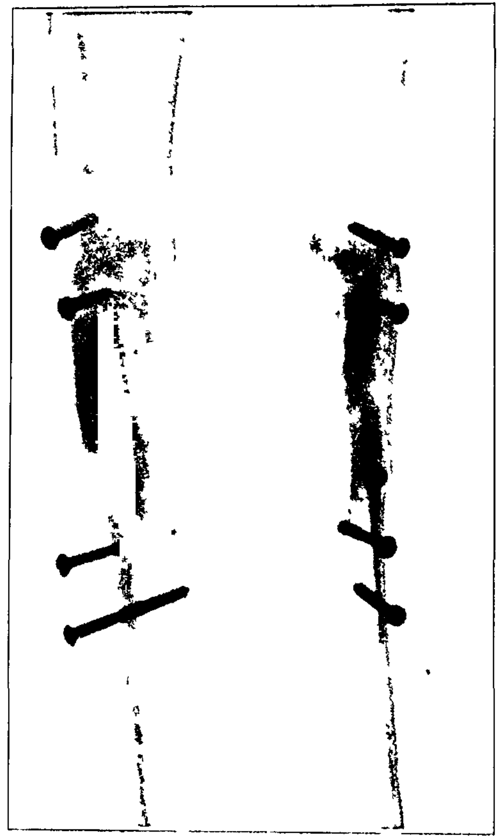

FIG. 3-E

Later roentgenogram showing further bone dissolution. Two screws have been removed.

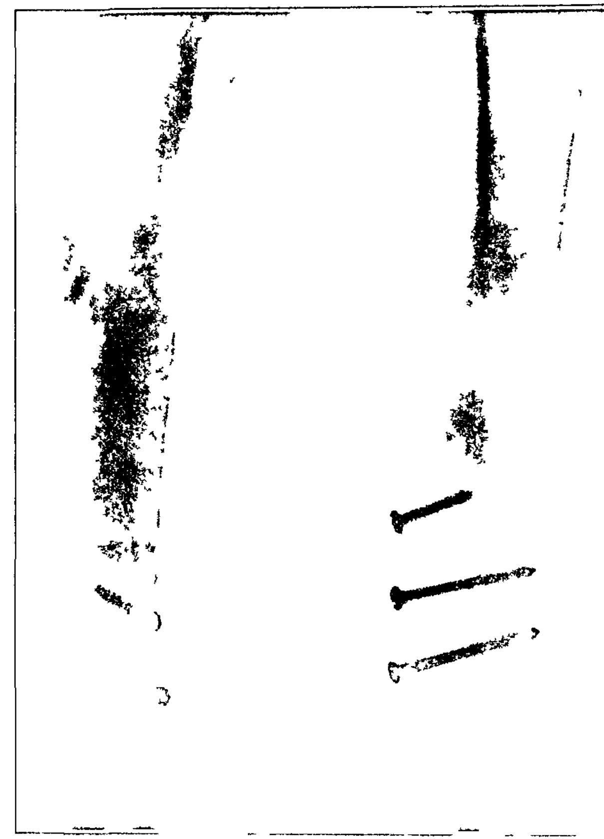

FIG. 3-F

Two months later, showing sound structural union. The patient was walking without support.

FIG. 4-A

Case 5. May 1942. Non-union on admission, seven months following accident.

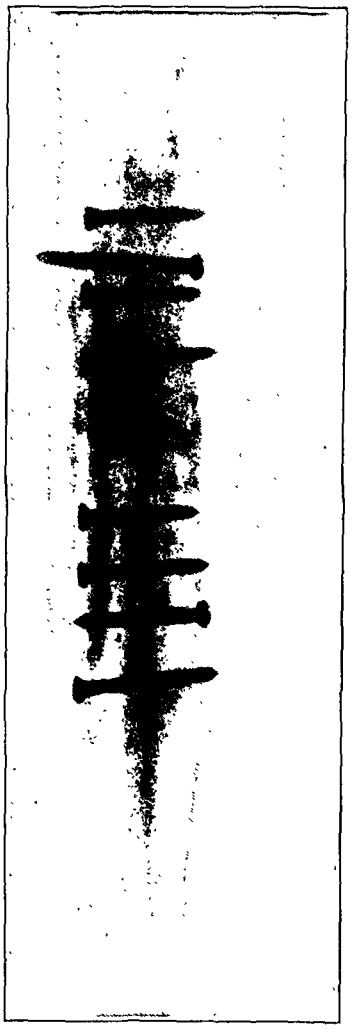

FIG. 4-B

October 1942, showing dual graft as depicted in Figure 1-B and following refracture of the ordinary sliding graft.

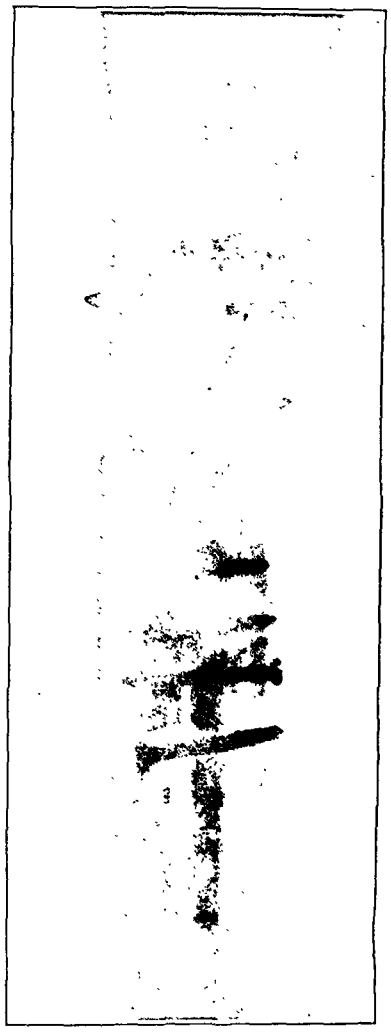

FIG. 4-C

October 1943, showing second accidental refracture.

to unite after a standard inlay, onlay, or sliding graft, such as in Case 5, a dual graft is resorted to, one component of which is of the standard type on the inner aspect, the other consisting of the longitudinal section and transfer of the fibula as described. Where close side-to-side approximation of the tibial and fibular fragments is not attainable after longitudinal section, a semi-osteotomy at one or both ends of the fibula may be required, as illustrated in Figure 1-C.

IMPRESSIONS

In four of the six cases cited, resort to extraordinary method was considered the only alternative to amputation. Union was obtained in all six cases; although in one, refracture accidentally occurred after the patient had walked several months without support.

Several additional areas of bone formation are created between the four main fragments. All fragments have an intact circulation. The end effect of a synostosis between the two bones results in an additional weight-bearing column as well as an added brace against horizontal strain, angulation, and movement between the tibial fragments.

In carefully selected, infected, non-unions with medial draining sinuses, the infected area can be completely avoided, and union can be secured in spite of considerable bone defect. Under the protection of the sulfonamides or penicillin, this operative procedure can be executed without hazard to life. The last three patients were protected during and

FIG. 4-D

All screws were subsequently removed.

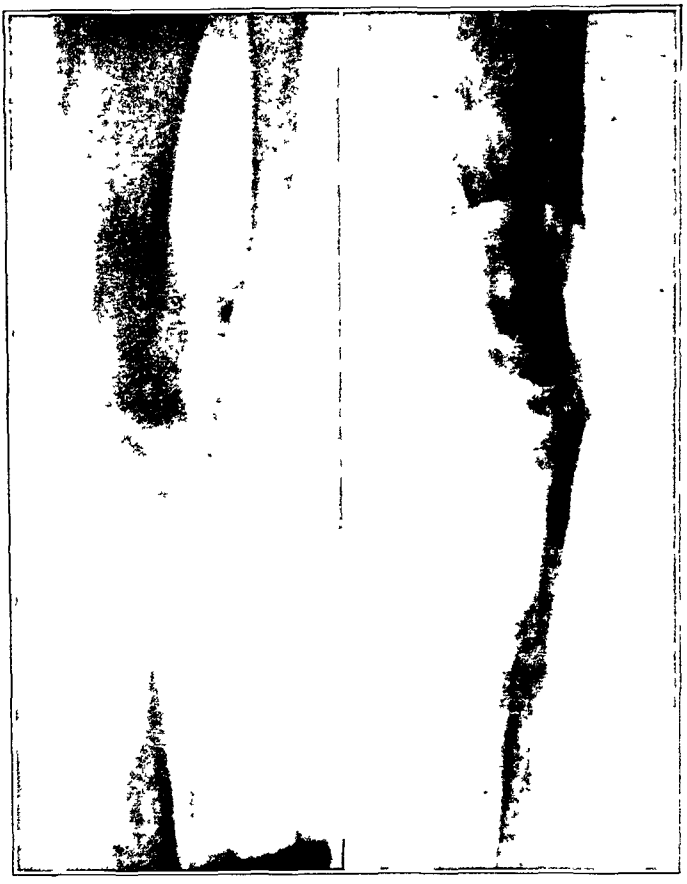

FIG. 4-E

December 15, 1943, showing condition two months after the removal of the screws. Patient is again ambulatory with plaster guard.

after operation by a concentration of sulfadiazine of five to ten milligrams per 100 cubic centimeters of blood, together with local "frosting" with sulfanilamide.

In spite of the sulfonamides and careful pressure dressings, the last two cases were complicated by prolonged drainage of a serous type. It is thought that not enough attention was paid to the unsound and scarred condition of the skin overlying the anterolateral surface of the tibia, and that a skin plastic operation should have been done in several of these cases as a preliminary procedure to the bone work. The screws used were of the S.M.O. type, and were all removed. Though there is no proof, it is thought that the combination of metal and sulfonamides with the presence of pre-existing low-grade infection led to the sinuses. Rarefaction was seen around a number of the screws. After union had been secured, the screws were removed. Some were found loosened and surrounded by granuloma; others were found tightly secured. Prompt healing was experienced after the removal of the metal and surrounding granuloma. As a precautionary measure, the author has reverted to the exclusive use of vitallium screws. Because he is of the opinion that firm fixation in all planes is necessary to assure union in simple fractures, and because he believes that failures frequently result from insufficient internal fixation, overemphasis, resulting in an excessive use of metal in the last three cases, may, in and of itself, account for the postoperative drainage. The splintage afforded by a massive graft plus the two strong fibular fragments would appear to require less screw fixation than a simple case of plating.

Prior to the use of chemotherapy, the hazard to life seems to have been too great to merit such radical surgery. Three of the cases cited were treated prior to, and the last

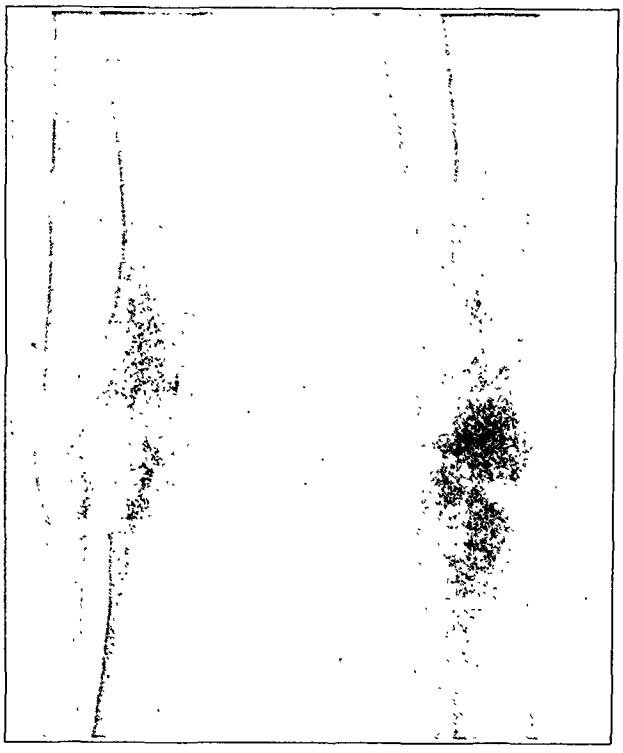

FIG. 5-A

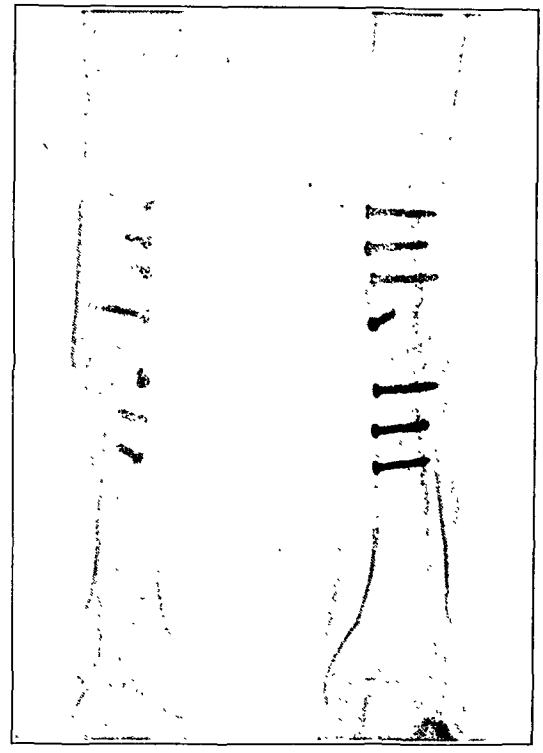

FIG. 5-B

Fig. 5-A: Case 6. April 1943, showing typical pseudarthrosis following plating of compound fracture. Note the close approximation of the fibula.
Fig. 5-B: July 1943, showing dual graft after the manner depicted in Figure 1-A.

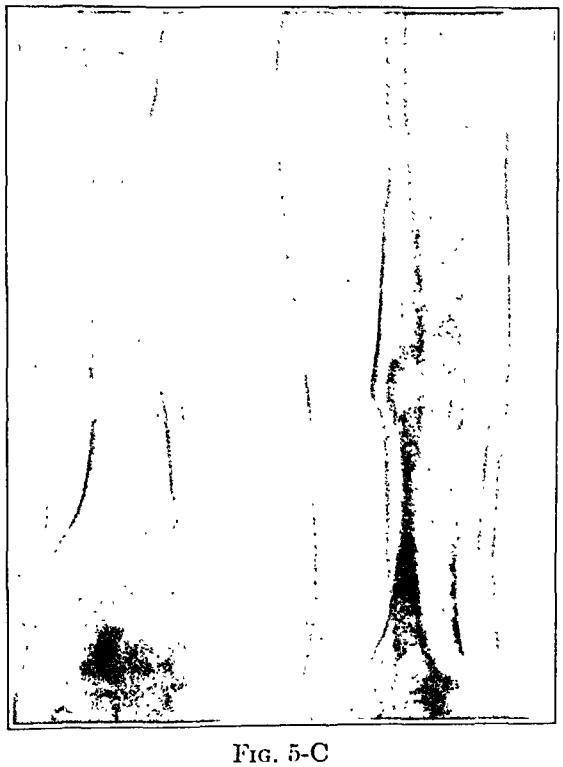

FIG. 5-C

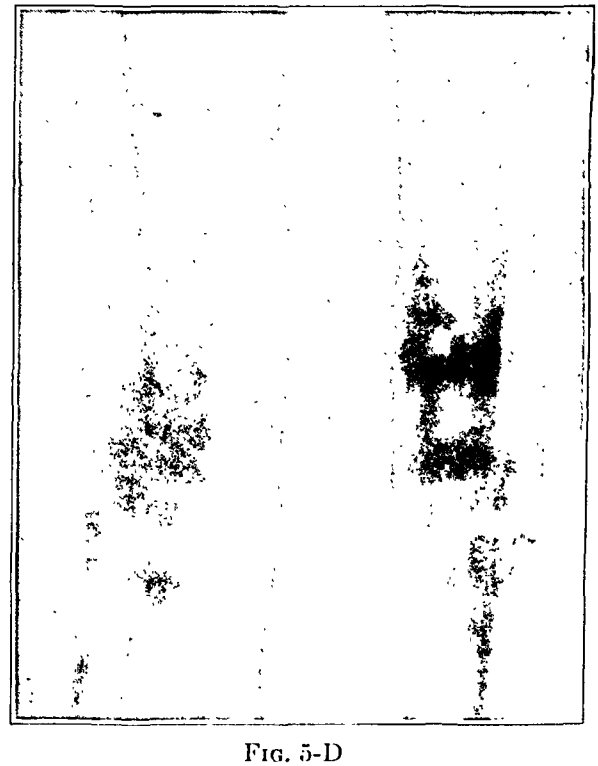

FIG. 5-D

Fig. 5-C: Three months later, screws have been removed because of rarefaction.
Fig. 5-D: December 1943, five months following the dual graft.

three subsequent to the advent of the sulfonamides. It is felt that chemotherapy has definitely eliminated the extraordinary risk, and so has enlarged the scope of the operation.

1. DAVIS, A. G., AND FORTUNE, C. W.: Compound Fractures. J. Bone and Joint Surg., XXV, 99 (Figs. 1-A, 1-B, and 1-C), Jan. 1943.

DISCUSSION

DR. HENRY MILCH, NEW YORK, N. Y.: The usual type of tibial pseudarthrosis can be fairly well controlled by drilling, bone chips, and osteoperiosteal or massive bone-grafting. The orthopaedic surgeon's headache comes not from these but from the relatively infrequent case where one or even more of the simpler procedures have failed. In the therapy of these cases, many different bone-grafting operations have been devised and successfully employed. The use of the fibula as the source of the graft dates back to 1905 when Huntington perfected the operation originally suggested by Hahn and subsequently improved by Codivilla. This operation has two main drawbacks:

1. It is a two-stage operation.
2. In the event of non-union at either site of implantation. the splinting action of the fibula is lost. and the patient may be left with a flail leg.

Indeed it was such fears expressed by a patient to whom the Huntington operation was proposed that led to the development of the synostosis operation which was reported in 1939.*

The idea of cross-union which formed the basis of that operation seemed to be mechanically sound, in that it employed an engineering device commonly used for the dispersal of stress. When consideration was given to the unyielding union which resulted from crossing the forearm bones, the failure to adapt it to tibial pseudarthrosis rather than its successful application, seemed the more surprising.

It was, therefore, extremely gratifying to learn that Dr. Davis had come to the same conclusion. and had actually made use of the principle of cross-union for some years before the synostosis operation was described. What is still more remarkable is that. as regards the technique of the tibiofibular synostosis, both operations are very closely alike. Dr. Davis has, however, supplemented this part of his operation by two additional measures. The first of these is in the use of the onlay graft, the second in the use of screw fixation.

The merit of the onlay graft in the treatment of non-union hardly warrants comment at this time. It is to be noted that in addition to its osteogenic function, the firm fixation of the free graft on the side opposite that of the fibular graft serves a valuable purpose in counteracting the tendency to outward bowing which usually develops in these cases.

The method of fixing these grafts by means of screws is logical and in accord with the present trend in surgical technique. Its value in maintaining contact during the period of consolidation is evident. On the other hand, as Dr. Davis himself has noted in comment on Case 5, the failure may be attributed "to the low-grade infection combined with probable electrolytic action around the screws".

This appears to be the crux of the whole presentation. On traditional grounds, it would seem that wide exposure of the medullary cavity of the fibula, even to passing contact with an infected area, must inevitably lead to failure. Yet, the results in Cases 1 and 4 indicate that this is not invariably true. If it be assumed that, with the use of the sulfonamides and the promised release of penicillin, plastic operations can be undertaken with greater confidence than in the past, Dr. Davis' contribution opens startling possibilities. In fact, it provides a method for the surgical creation of a sort of involucrum within which the infective process can be brought under control without the loss of stability of the limb. If further experience should confirm the present observations, the procedure might prove of inestimable value in the treatment of the extensive injuries which the present conflict may be expected to produce.

Like all the special operations designed for the cure of persistent non-union, this operation is not intended for routine use. The combination of the massive graft with the synostosis operation is most ingenious, but it should not be forgotten that the onlay graft makes one operation, the synostosis constitutes another operation, and both together make a real operation. It should be reserved for the intractable case.—for the case where the simpler procedures have already failed or where conditions are such that they would in all probability be unsuccessful. It cannot be denied that Dr. Davis has boldly ventured into fields that most of us would have feared to tread. It is, however, a tribute to the solidity of his surgical indications that he has collected a series of only six cases over a period of fifteen years.

DR. J. ALBERT KEY, ST. LOUIS, MISSOURI: The use of the fibula as a graft in bridging defects in the tibia or providing an accessary bone for the treatment of non-union of the tibia was first brought to my attention some years ago by the paper of Dr. Philip Wilson on the use of this method in the treatment of congenital pseudarthroses in children. At that time I was not very favorably impressed. In subsequent years, having failed to obtain union in some of these cases by the use of autogenous grafts (including dual grafts) I have been much more favorably inclined to the use of the fibula. I think that Dr. Davis' method of using this bone is a very ingenious one. However, I think that the operation is technically difficult and should not be undertaken lightly. Certainly his results are excellent.

* MILCH, HENRY: Synostosis Operation for Persistent Non-Union of the Tibia. A Case Report. J. Bone and Joint Surg., XXI, 409, Apr. 1939.

NEUROSURGICAL INTERPRETATION OF DERMATOME HYPALGESIA WITH HERNIATION OF THE LUMBAR INTERVERTEBRAL DISC *

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When prehistoric man assumed the erect posture and began to use his upper extremities for lifting and carrying, he created a problem in low-back alignment and support that has plagued the human race and given rise to much pseudoscientific diagnosis and treatment of low-back and sciatic pain. In this rather unsatisfactory field, there has been a notable lack of careful study of the commonly associated organic neurological signs of sensory, motor, and reflex loss in the lower extremity, proper interpretation of which provides a better understanding of this syndrome. It is the purpose of this paper to present some clarifying neurosurgical observations on this subject, particularly in relation to the herniated lumbar intervertebral disc, based upon careful outlining of the areas of reduced sensation in 185 cases, with operative verification of the nerve root involved in ninety of these cases, nine by section of the nerve root (Table I).

From this study [7], it was found that a diagnostic area of single nerve-root or dermatome hypalgesia can be outlined in the majority of cases of herniated intervertebral disc for one of the nerve roots from the third lumbar to the second sacral. These dermatome areas extend continuously from the foot to the spine and are arranged in logical serial order from the inner to the outer side of the foot and leg, without significant overlap. This permits the drawing of a new dermatome chart of the lower extremity (Fig. 1), based upon definite hypalgesia from single nerve-root loss, and clarifies the present confusion of anatomical and neurological illustrations of the distribution of the sensory nerve roots in the lower extremity. This chart makes possible the identification of single nerve-root lesions caused by a herniated intervertebral disc or other compression, and accurately localizes the herniation at the disc next above the numbered nerve root.

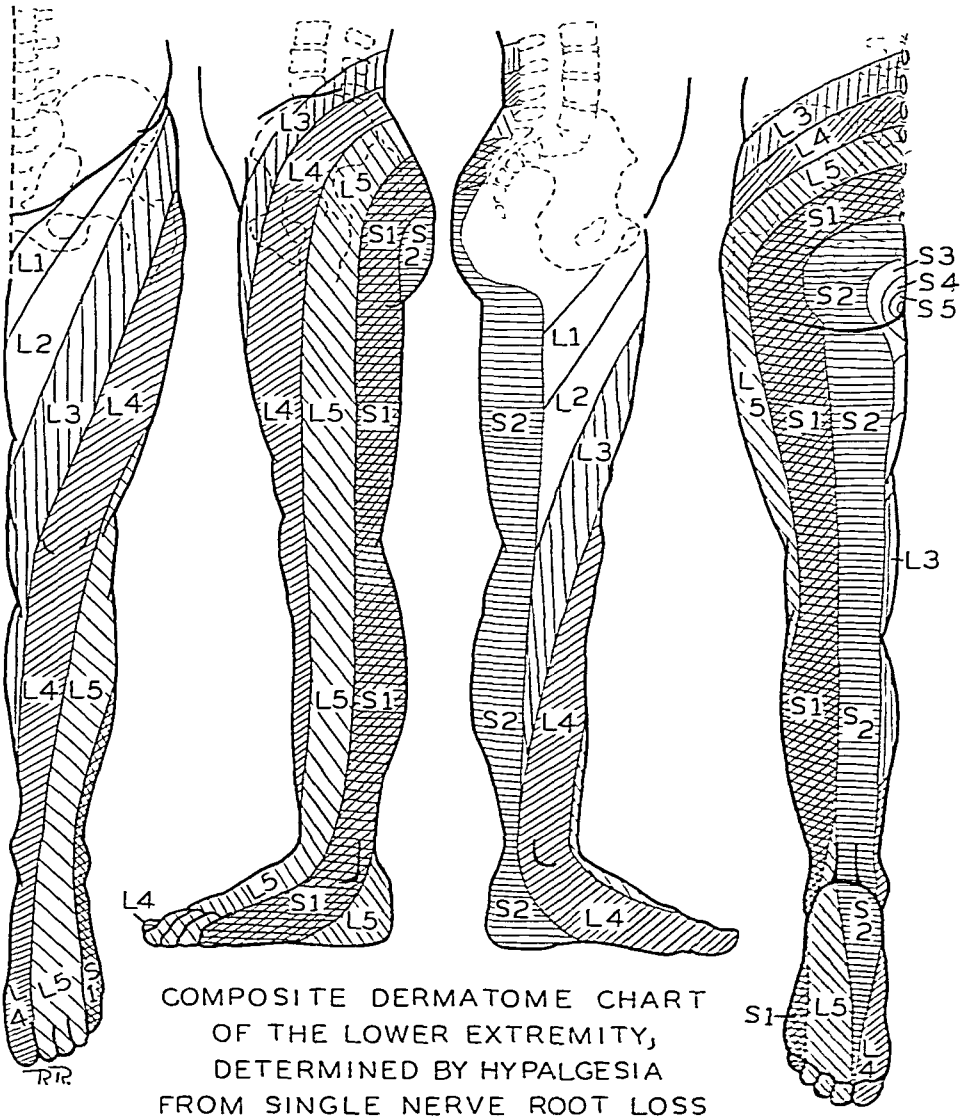
The nerve root most commonly compressed by a herniated intervertebral disc is the first sacral root, compressed by the fifth lumbar disc. These have been variously estimated at over 50 per cent. of all disc herniations.[11, 14] The pain caused by this lesion is commonly termed "sciatic", and radiates from the lumbosacral junction, over the buttock and posterior thigh and leg, to the lateral ankle and foot. It has been recognized for a long time that this pain is commonly associated with sensory loss [2], but interpretation of this organic neurological sign has been handicapped by lack of clear definition of the areas of the sensory dermatomes in the lower extremity, and by the common dictum that loss of a single nerve root produces no loss of sensibility [4]. Orthopaedic interpretation of this hypalgesia has tended to explain it on the basis of compression of nerve roots in the intervertebral canals, particularly the large fifth lumbar nerve root in the relatively small lumbosacral canal [17]; or, too frequently, organic neurological signs have been ignored, and a rather loose interpretation of referred, reflex, or neuritic pain has been given.

The anatomy of the first sacral nerve root should be better understood to appreciate its common isolated compression by a herniated fifth lumbar intervertebral disc (Fig. 2). This nerve root leaves the main dural canal above the fifth disc, lies well lateral in the flattened spinal canal at this level, has its ganglion situated beneath the first sacral lamina, and leaves the spinal canal through the first sacral foramen. This portion of the root measures three to four centimeters in length, is entirely intraspinal in the lumbar region, and could not possibly be involved by extraspinal lumbar pathology. Compression by a

* Read at the Annual Meeting of The American Orthopaedic Association, Cleveland, Ohio, June 7, 1943.

discrete herniation of the fifth lumbar nucleus pulposus occurs above the ganglion and below the union with the main dural canal; hence an intraspinal myelogram may not show a diagnostic defect for this disc herniation, or may show only a defect in the first sacral nerve-root sheath.

The herniating disc first stretches and elevates the posterior longitudinal intervertebral ligament at its weakest point lateral to the thicker mid-line portion. This ligament strain, or separation, probably is responsible for the usual limitation of pain, in the early stages, to the low back over the lumbosacral junction. The first contact of the herniating disc with the nerve root is on the anterior surface, where the motor fibers are located (Fig. 3). It is doubtful if this early contact with the motor fibers, with slight root displacement, causes radiating nerve-root pain. Pain more likely is produced when the nerve is compressed against the overlying ligamentum flavum or the lamina, which directly contacts the sensory portion of the root. The fact that the most dorsal sensory fibers of the root are those of the dorsal primary division, supplying the mid-gluteal region and the



COMPOSITE DERMATOME CHART
OF THE LOWER EXTREMITY,
DETERMINED BY HYPALGESIA
FROM SINGLE NERVE ROOT LOSS

FIG. 1

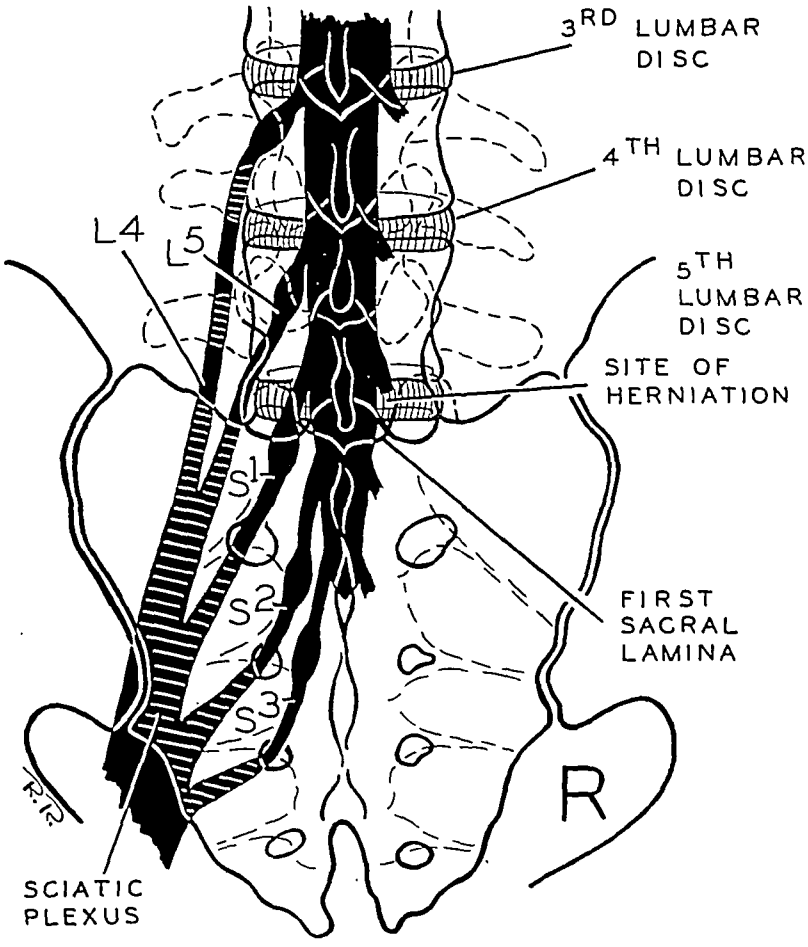


FIG. 2

Drawing over roentgenogram to show relation of first sacral and fifth lumbar nerve roots to intervertebral discs.

sacro-iliac ligament [12], may explain the early and more constant gluteal distribution of pain in these cases, which is commonly described by the patient as "hip" pain and formerly was interpreted as sacro-iliac pain.

As the herniation increases, the first sacral nerve root usually is flattened between the anterior tumor and the posterolateral ligamentum flavum, and often becomes so adherent to the herniation that sharp dissection is necessary to free it. Sometimes the nerve root is displaced laterally, and the tumor presents itself in the axilla of the first sacral nerve root, while occasionally it may be displaced medially to escape direct compression. A significant observation at operation is that rarely is any other nerve root involved or contacted by the frequent herniation of the fifth lumbar nucleus pulposus, and it seems necessary to interpret the pain, hypalgesia, and reflex loss in such a case as due entirely to first sacral nerve-root compression. This has been verified many times by a postoperative transient increase in the characteristic hypalgesia from the stretching of the nerve root during removal of the disc herniation, by prompt relief of pain on release of the first sacral nerve root, and by section of this nerve root in four cases.

The hypalgesia of first sacral nerve-root loss (Fig. 1) is found most easily and constantly on the lateral foot or posterolateral calf by the simple use of light pin prick or scratch. When this nerve root has been compressed long enough or severely enough to produce subjective numbness, or loss of ankle jerk, there can usually be outlined a continuous strip of hypalgesia extending from the little toe to the upper sacral spine, with a small area of analgesia on the lateral border of the foot or on the posterolateral calf. This dermatome hypalgesia can be outlined sharply, and is constant in its location; hence it is diagnostic for first sacral nerve-root loss, whatever the cause. It includes only the little toe; does not include the heel; covers the external malleolus; extends up the posterolateral calf, knee, and thigh, with its medial border about at the posterior mid-line; then curves slightly outward over the buttock and mid-gluteal region to the upper sacral spine, where it stops sharply at the mid-line. When this complete dermatome hypalgesia is present, the ankle jerk usually is absent. Lesser degrees of compression of the first sacral nerve root may show the dermatome hypalgesia in only the foot and leg, with the ankle jerk only reduced, or varying with use of the leg.

Undoubtedly there will be questions concerning this finding of a discrete and continuous dermatome sensory loss from single nerve-root compression, because so many well-qualified neurologists have failed to find it, and because it is in disagreement with the

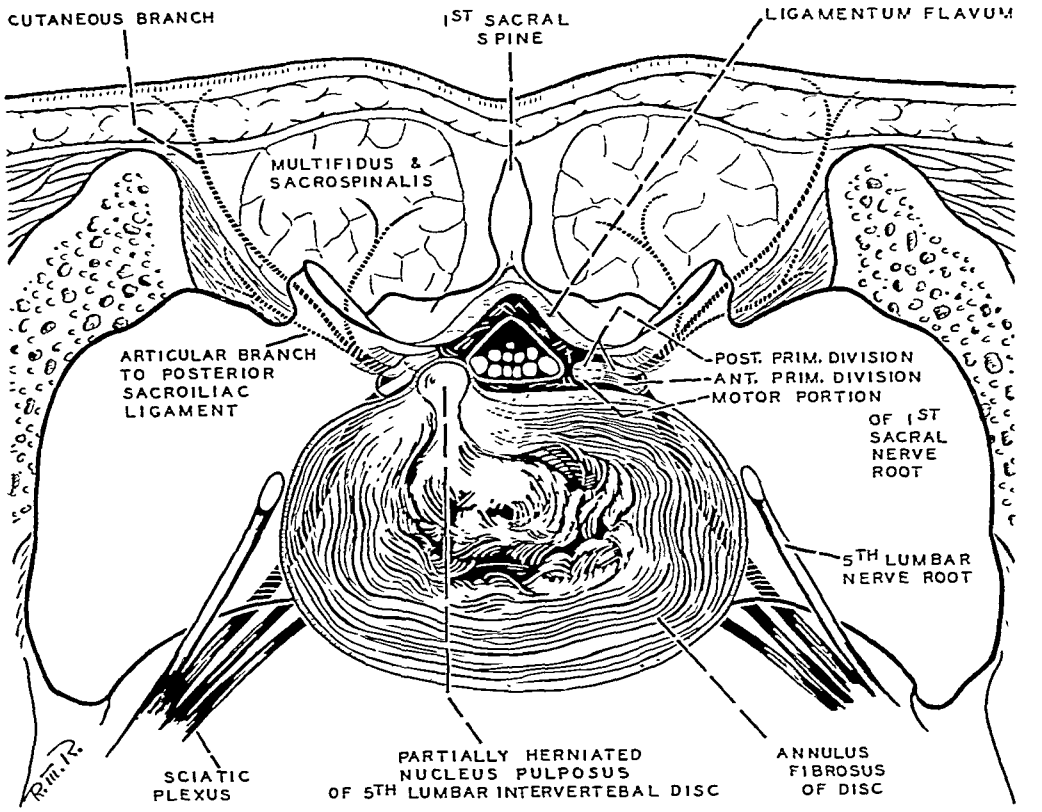


FIG. 3

Reconstructed cross section at the level of the fifth lumbar intervertebral disc to show the relation of the herniated nucleus pulposus to the first sacral nerve root.

findings of both Head and Foerster concerning the dermatomes in man. To this it can be said only that the observations of this study have been confirmed too many times in proved surgical cases (Table I) to doubt their reality, and it is asked that others look for them with this dermatome chart (Fig. 1) and technique in mind, regardless of preconceived ideas or accepted authority. The findings are best elicited by very light pin prick or scratch, which passes from the slightly hypalgesic to the normal sharper zone; the patient should understand that he is to report an increase in the sharpness of the pain. The reduced sensation is so slight in the upper portion of the dermatome that it is not easy to detect; or it may be absent or indistinct above the knee, when the nerve-root function is not completely interrupted. However, this does not alter the interpretation of discrete involvement of the first sacral nerve root, when the characteristic dermatome loss can be demonstrated in any portion below the knee. This opinion is based upon the finding of first sacral dermatome hypalgesia in 116 cases. The site of the lesion in sixty was verified by surgical exposure, four by nerve-root section.

The nerve root next in frequency to be involved by herniated disc or low-back pathology is the fifth lumbar. This root at its exit from the main dural canal lies over the fourth lumbar disc (Fig. 2), and is one to two centimeters in length before its entrance into the fifth lumbar intervertebral canal. In the lower part of the canal, it crosses the lateral surface of the fifth disc, where it may be involved by hypertrophic or compressive vertebral pathology. It then passes over the smooth anterior surface of the lateral sacrum to join the first sacral nerve and sciatic plexus. It has no contact with an enlarged fifth lumbar transverse process.

The syndrome of fifth lumbar nerve-root compression is difficult to diagnose, because

TABLE I

DISTRIBUTION OF CASES OF HERNIATED INTERVERTEBRAL DISC WITH DERMATOME HYPALGESIA

Dermatome	No. of Cases	Per Cent.	Verified at Operation	Verified by Nerve-Root Section *
Third lumbar	2	1.1	–	–
Fourth lumbar	19	10.3	9	2
Fifth lumbar	47	25.4	20	2
First sacral	116	62.7	60	4
Second sacral	1	0.5	1	1
Totals	185	100.0	90	9

* Cases verified by nerve-root section are included with those verified at operation.

it has no characteristic reflex loss and does not present a dermatome area of hypalgesia which can be outlined as easily as that of the first sacral nerve root. However, the pain or subjective numbness usually can be noted to be somewhat more lateral on the thigh, anterolateral on the leg, and more on the dorsum of the foot when it extends that far. The characteristic hypalgesia of loss of the fifth lumbar nerve root (Fig. 1) is found on the dorsum of the foot, including the three middle toes, and from there extends spirally over the anterolateral leg, and lateral knee and thigh, curving around the buttock to the spine at the lumbosacral junction. In addition, there is a wedge-shaped area of hypalgesia on the sole of the foot, extending from the three middle toes, over the lateral heel to a point on the tendo achillis. This area is difficult to outline because of the usual callus on the sole. The Achilles or patellar reflex may be reduced, but not absent, with this nerve-root loss. This dermatome was found in forty-seven cases, in twenty of which the site of the lesion was verified by operation, in two by nerve-root section.

Compression of the fourth lumbar nerve root is not so common, but presents a very characteristic syndrome. The pain radiates well laterally over the greater trochanter, down the anterolateral thigh, and over the patella to the anteromedial tibial surface, inner malleolus, and great toe. The dermatome hypalgesia follows a similar course from the medial foot to the lower lumbar spine (Fig. 1). With complete nerve-root loss, the knee jerk is absent; with lesser involvement, it is only reduced. This dermatome was found in nineteen cases, and the site of the lesion was verified by operation in nine cases, by nerve-root section in two cases.

The syndrome of a lesion of the third lumbar nerve root is rather rare, and was not well established in this study, but it was found quite definitely in one patient with high-lumbar pain radiating around the crest of the ilium to the anterior thigh and medial knee, and with dermatome hypalgesia in the corresponding area (Fig. 1). Roentgenograms of this patient showed a discrete metastatic lesion in the lower part of the second lumbar vertebra on the same side, presumably compressing the third lumbar nerve root. A second case has not been verified.

The second sacral nerve root is not involved by a herniated intervertebral disc unless the herniation is very large and compresses several nerve roots of the cauda equina. An exception can occur when there are six well-formed lumbar vertebrae, and herniation of the sixth disc develops. The author has found no herniation in this location, but in one case of persisting pain and hypalgesia of the first sacral nerve root, the nerve root crossing the sixth lumbar disc was cut, the author thinking it was the first sacral, and thus the dermatome hypalgesia from section of this nerve root was outlined. The area of both subjective and objective numbness corresponded to the distribution of the second sacral nerve root (Fig. 1),—down the inner buttock to the posteromedial thigh, leg, heel, and sole. This completes the dermatome chart of the lower extremity, except for the first and second lumbar nerve roots in the upper anterior thigh.

The value of this composite dermatome chart is that it furnishes a key for the diag-

nosis of individual nerve-root loss in the lower extremity, which is more accurate than the myelogram in typical syndromes of progressive low-back and unilateral "sciatic" pain, caused by a herniated intervertebral disc. It does away with the necessity or warrant for doing difficult and disturbing intraspinal myelograms in the great majority of these cases. Anyone who has had experience with myelograms appreciates the fact that they occasionally fail to show a herniation which is found at operation, or may show a false defect leading to negative exploration[8]. Localization of the nerve root involved by the method of dermatome hypalgesia is so accurate that persisting pain in a nerve root, after unsuccessful surgery of the herniated disc, or from other cause, can be relieved by section of the nerve root involved. This has been demonstrated six times in this series of cases. In four cases, the first sacral nerve root was adherent in the old disc scar; in one, a small neurofibroma was found at the place of emergence of the fourth lumbar nerve root; and one was a compressive lesion of the fifth lumbar nerve root in its canal.

A few remarks may be added concerning neurosurgical interpretation of herniated intervertebral disc. With hundreds of cases now proved by neurosurgical demonstration of the pathology, most of which occurred in patients who initially presented low-back pain without "sciatic" radiation, the question may well be raised, how can this early stage of pathology of the intervertebral disc be differentiated from the many other conditions postulated by orthopaedic surgeons as causing low-back pain. The author must confess that he cannot differentiate the early low-back pain of herniating disc from the various diagnoses of myofascitis, ligamentous strain, facet syndrome, hypertrophic arthritis, or congenital abnormalities, and is led to suspect that the majority of these variable, recurring low-back pains are in reality the early stages of herniating disc. One can only theorize on this subject, for the pathology at this stage is not often demonstrable; but certainly one seems justified in so interpreting those cases in which the diagnosis of herniated disc is later proved.

The sensation of sudden slipping which occurs in so many backs, often brought on by insignificant stooping strain and followed by varying disability, seems to necessitate some freely movable structure in the back which shifts position at these times. It is difficult to conceive that movement between the articular processes causes this sudden pain, but it is rather easy to understand that a loose nucleus pulposus, which shifts position within the annulus fibrosus of the disc, could cause this pain (Fig. 3). It is well known that the nucleus pulposus commonly undergoes degeneration beginning in the third decade [13], and at this time, when men like to think they are as strong as they ever were, hydraulic pressure, in addition to a loose nucleus, favors posterior displacement of the nucleus in the forward-bending position. The annulus probably is partly ruptured at this stage, and the posterior longitudinal ligament is stretched during the attack of low-back pain. This is the stage so difficult to differentiate, and certainly is not a stage for the application of surgery, for the symptoms usually subside under conservative treatment. A suggestion might be made concerning treatment at this time. Assuming that a fair percentage or a majority of these low-back syndromes result from early herniating-disc pathology, one may ask why some well-directed manipulation should not be applied in an effort to reduce these early displacements of the nucleus pulposus. At least efforts directed in this manner would seem in order, with our present knowledge of the frequency of herniated disc.

In view of the recognized greater frequency of herniation of the fifth lumbar disc than of any other, more attention should be paid to this disc in roentgenograms of the lumbar spine. [1, 18] The routine roentgenograms of the lumbosacral spine do not show the fifth disc satisfactorily, because of the 30 to 40-degree angle of the sacrum, and the oblique manner in which the rays pass through the disc in both anteroposterior and lateral views. Narrowing of the fifth disc may or may not be of significance, depending upon the presence of a transitional type of fifth lumbar vertebra. Narrowing of the fourth or third disc is more significant of herniation pathology. The roentgenologist should be given some indi-

cation of the suspected level of the disc involved, based upon the dermatome hypalgesia.

Other pathology observed in roentgenograms should not alter the interpretation of the location of the lesion of a single nerve root by its dermatome hypalgesia. It has been emphasized previously that the first sacral nerve root cannot possibly be involved by any extraspinal lumbar pathology. Even spondylolisthesis of advanced degree rarely leads to symptoms of the first sacral or other nerve roots, because the dorsal arch of the fifth lumbar vertebra remains in alignment, and the nerve roots are not compressed by the forward displacement of the body. Hypertrophic spurs, so often seen in men of middle age who have done much heavy back work, are not commonly located where they would contact or compress a nerve root [3], and usually are more marked at the upper lumbar level than in the lower lumbar spine where nerve-root symptoms more often appear. A bifid first sacral spine is usually a minor anatomical defect, possibly predisposing to low-back trouble, but it is not related closely enough to nerve roots to explain unilateral dermatome pain and hypalgesia [19].

The syndrome of reflex pain, as described by Steindler and others [6, 15] is difficult to evaluate. It should be emphasized that reflex superficial pain from some deep focus of pathology necessitates that the pain remain in the same segment or segments from which it originates, and that it remain on the same side as its origin. There is little evidence that such reflex pain can extend up or down the spinal cord to other segments or cross to the opposite side. The mechanism of reflex pain is not very well understood [9]. Some authors believe that it is due to faulty localization from dominance of the superficial pain system [10], or has developed from an irritable segmental center in the cord [16], or involves a central summation of deep and superficial sensations which might permit relief by novocain interruption of any portion of the complete reflex arc. It would be interesting to know the later history of the cases diagnosed by Steindler as reflex sciatic pain, to learn if any signs of organic nerve-root loss subsequently developed in these patients.

Surgery of herniated intervertebral disc has been excellently presented in so many papers that time will be taken only to emphasize a few important points. A conservative attitude certainly should be maintained, and only the seriously and chronically disabled patients should be operated upon. Temporary, disabling low-back pain develops in nearly every one at some time in his life; much of it probably is related to pathology in the lower lumbar discs. Some back protection always will be advisable after this episode, or for any laborer in his thirties, regardless of back trouble. However, surgical relief should not be postponed too long after typical symptoms of herniated disc with dermatome hypalgesia develop, when unsatisfactory progress is being made, and the economic situation requires earlier restoration to some work capacity.

While prompt relief from the radiating nerve-root pain of a herniated disc usually can be promised after surgical release of the compressed nerve root, there are some possibilities of recurrence from further herniation or from dense adherence of the nerve root in the region of the traumatized disc. In such a case of persisting nerve-root pain, it may be advisable to reoperate and deliberately cut the nerve root above the place of adhesion. Loss of a single nerve root does not cause disturbing sensory or motor loss. In fact most patients with dermatome hypalgesia are unconscious of any sensory loss, unless they have irritative paraesthesia. After nerve-root section, this paraesthesia disappears, and the patient may state that the region feels less numb than before.

The advisability of spine fusion in selected cases of herniated intervertebral disc is difficult to determine. The patient who presents predominantly or solely nerve-root pain surely should not have a spine fusion, even though the pain recurs after the disc operation. Nerve-root section then would be a more logical procedure. The patient with prominent low-back pain along with nerve-root pain may have only an actively stretched posterior longitudinal ligament, which may be relieved and stabilized by removal of a partly herniated nucleus pulposus. It seems better judgment and more conservative surgery to with-

hold fusion in these cases until continued low-back symptoms after disc operation warrant such a procedure. The patient with seriously disabling recurring low-back pain without nerve-root signs, still presents a problem for diagnosis and treatment. These unstable backs probably represent a movable nucleus pulposus still retained within a weakened or stretched annulus fibrosus. Spine fusion may be the procedure of choice for stabilization of these backs, although exploration of the fourth and fifth discs may be indicated first. If a concealed loose nucleus pulposus can be found and removed from the disc, the more time-consuming fusion operation should be postponed.

SUMMARY

1. Herniated lumbar intervertebral discs commonly compress single nerve roots, and present associated dermatome hypalgesia in the lower extremity, which is accurately diagnostic of the location of the lesion.

2. A new dermatome chart of the lower extremity is presented, based upon hypalgesia from proved single nerve-root loss. These findings are in disagreement with the common dictum that loss of a single nerve root produces no loss of sensation.

3. The nerve root most commonly compressed by herniated intervertebral disc is the first sacral nerve root. Recognition of the syndrome of lesions of the first sacral nerve root, with its characteristic dermatome hypalgesia and loss of the ankle jerk, removes any extraspinal lumbar pathology as a possible cause, as this nerve root is entirely intraspinal until its exit through the first sacral foramen.

4. Subjective and objective numbness and reflex loss are organic neurological signs, not explainable from any possible reflex reference from obscure distant pathology. Numbness over the distribution of a single nerve-root dermatome necessitates a lesion directly and discretely involving that root.

5. The common occurrence of pathology of the fifth and fourth lumbar discs, leading to later herniation, should be considered more often as a possible explanation of early attacks of low-back pain; and manipulative treatment should be directed to possible reduction of this beginning herniation.

6. Roentgenograms of the lumbar spine should be directed to the disc indicated by the finding of unilateral single dermatome hypalgesia. Other pathology seen in roentgenograms, not directly related to that nerve root, should not be used to explain this organic neurological finding.

7. A conservative attitude should be maintained in surgery of the herniated disc, for in many early cases improvement occurs without surgical interference; however, with or without operation, these patients present some permanent disability which requires back protection.

8. Spine-fusion operation is not often indicated in herniated disc, because of both the unreliability of preoperative selection of cases which will require it, and the recognized imperfect results of this time-consuming procedure.

9. Deliberate section of a nerve root sometimes is warranted and effective to relieve persisting single nerve-root pain after an operation for a herniated disc. The nerve is identified by its dermatome hypalgesia.

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DISCUSSION

Dr. R. D. Schrock, Omaha, Nebraska: It has been my privilege to watch the development of this dermatome chart as presented by Dr. Keegan, and also to observe the degree of accurate localization of the involved nerve root that can be determined by a meticulous clinical examination with apparatus no more complicated than a straight pin. Dr. Keegan has been able to demonstrate that lipiodol injection is no more accurate or dependable than a carefully made clinical diagnosis. His dermatome demonstration will be of definite value to each of us who is willing to spend a little more time on the details of clinical examination, for accurate localization of disturbed response to pin prick.

Dr. M. N. Smith-Petersen, Boston, Massachusetts: We must differentiate between two conditions. In a lesion of the intervertebral disc, we have a condition which results in pressure or tension of a spinal nerve and interference with its function, and, therefore, frequent sensory changes, as well as diminished or absent reflexes. In a lesion of the sacro-iliac joint, we have no pressure or tension of spinal nerves; their function, therefore, is not affected, and there are no sensory changes, and no reflex changes except those secondary to protective muscle spasm.

I am very happy that Dr. Keegan did not use the term sciatica more than he did. I think it is a common fault of most neurosurgeons to use this term very loosely without stating what portion of the sciatic nerve is involved. When we speak of the sciatic nerve, we must remember that it is made up from five spinal nerves, the fourth and fifth lumbar, and the first, second, and third sacral. We must be specific and state what part of the sciatic nerve is involved. Dr. Keegan's chart of dermatomes is entirely different from any I have seen. It is different from Dr. Foerster's; I have never seen the fifth lumbar extending all the way up to the gluteal region. I wonder if Dr. Keegan will not enlarge a little upon that, and tell us whether some of that extensive distribution of the lumbar and sacral nerves he describes may not be due to the usual overflow.

Dr. E. W. Ryerson, Chicago, Illinois: I have recently heard several neurological surgeons use the word hypalgesia. Do they mean hypo-algesia or hyperalgesia? I can see no reason for using an indefinite word.

Dr. Arthur Steindler, Iowa City, Iowa: There is nothing to add to what Dr. Keegan has said. He presented a marvelous diagram of the sensory distribution of the sacrosciatic plexus covering the entire extremity. But I want to emphasize again that we should no longer refuse to admit that some of the pain

which is called sciatica is not of mechanical origin. For a number of years I have been trying to convince the orthopaedic surgeons that some of the pain is of true reflex character, and is not mechanically produced. Of this, we have many analogous situations in the human body. I would not dare to claim the reflex character for some cases of sciatic pain, knowing that such explanation is much less plausible than the simple mechanical concept of pressure on the spinal roots, if I had no good and sufficient reason for doing so. All our anatomical studies have shown us that all back structures are supplied by the posterior primary division, and all anatomists to whom I have talked have agreed on that point. They are also agreed that there is no connection between the sciatic and the posterior primary division which innervates the skin over the back, and the ligaments, muscles and tendons, and their attachments. Now we are confronted with some patients, as you all know, with sciatic radiation which does not follow strictly the anatomical distribution of the sciatic, either according to Keegan's or Foerster's or any other anatomical diagram. Such a case shows no neurological signs, no objective sensory changes, no paraesthesias, no analgesia; this pain is comparable to the neurological pain of the trigeminus; it is diffusely but anatomically distributed over the territory belonging exclusively to the anterior primary division. Now, if this radiating pain is absolutely and completely abolished by injecting novocain into a territory that has no connection with the primary division, as I indicated above, there is no other explanation possible, I believe, except that of reflex transmission through the spinal cord. It is all right to say it is a theory, but these observations stand. The cases may not be so numerous as we believed them to be in the beginning, but no argument can deny their existence, and I challenge you to give any other explanation of the nature of radiating pain in this particular type of case. We must break with the iron-clad tradition that all cases of sciatic radiation, without exception, are mechanically produced. This is all I claim.

DR. ALAN DEF. SMITH, NEW YORK, N. Y.: The work that Dr. Keegan has presented shows the value of cooperation between the neurologist and orthopaedic surgeon in attacking this problem. We have managed these cases in a similar way at the New York Orthopaedic Hospital, and we have also arrived at the conclusion that an accurate clinical examination is more valuable than the injection of lipiodol or some other opaque substance. We have used a different chart of dermatomes from that which Dr. Keegan has used, but we have arrived at the same result.

I would like to make a plea for the greater use of spine fusion in these cases. In the first place it is quite probable that an instability of the lumbosacral joint is the underlying cause of the weakening and subsequent rupture of the disc. In any event, we have found a high proportion of unstable lumbosacral joints in these patients. After the nucleus has been lost from the disc, the disc is certain to become thinner and its physiological action will have been lost. This is quite likely to result in a painful joint. It is easy to do a spine fusion in connection with the disc operation, and this usually entails only about three weeks' additional disability in bed. In the patients who have been operated upon at the New York Orthopaedic Hospital, better results have been obtained in those who have both the removal of the nucleus pulposus and the spine fusion.

DR. J. JAY KEEGAN, OMAHA, NEBRASKA (closing): I appreciate the discussion of my paper. In answer to Dr. Smith-Petersen, I wish to say there still is some confusion in my mind concerning the terms referred, reflex, and radiating pain. Undoubtedly pain can be referred from some distant deep focus in a reflex manner to a superficial nerve distribution. I used to call this referred pain, but perhaps reflex pain is a better term to distinguish it from the common reference of pain to the end distribution of any nerve which is irritated.

The use of the term "sciatica" sometimes seems necessary to obtain a common level of thinking from which further differentiation may proceed. I believe most neurological surgeons as well as orthopaedic surgeons have relegated this term to the limbo of the terms rheumatism, eczema, and catarrh.

In regard to the disagreement of my dermatome findings with those of Dr. Foerster, I wish to say that I have as much respect for his very important contribution to this subject as has any one, and have tried to harmonize the differences. By superimposing his dermatome findings on the dorsum of one foot it was observed that the fourth lumbar dermatome included only the great toe, and the first sacral dermatome only the little toe, with the three remaining middle toes supplied only by the fifth lumbar dermatome, in agreement with my chart. The chief point of disagreement with both Foerster and Head is their failure to find these dermatomes extending above the knee to the spine, as I have found. I cannot explain this disagreement, as I am quite certain of my findings and am sure that others can confirm them. An important point made in my paper is the interpretation of the progressive descent or radiation of pain of single nerve-root compression from the lumbosacral spine to the foot, as evidence of pain endings of that root in that distribution.

The absence of significant overlap of the dermatome areas of my chart are in agreement with Head's chart and not Foerster's, which is explainable on the basis of methods used. Head plotted his dermatomes chiefly from areas of herpetic eruption, and mine are from definite sensory loss from single nerve-root compression, both representing an objective manifestation of nerve-root disturbance and perhaps more accurately the primary innervation of that nerve root. Foerster used the method of remaining sensation after nerve-root section above and below, thus showing the important overlap of secondary sensation. Also Foerster's statement that loss of a single nerve root results in no loss of sensation was modified in his later

text, and evidently applied more to complete loss of pain than hypalgesia, as tested in my study. There is no question in my mind concerning the reality of some pain loss in the lower extremity from single nerve-root compression, stretching, or section. The method of testing is very simple, use of light pin prick or scratch by the free hand, beginning in the leg or foot where the dermatome areas of hypalgesia are most easily demonstrated. The pin is passed from the slightly reduced zone to the normal-sharper zone, and the patient reports when the pain definitely becomes sharper. The line of transition is drawn with surprising constancy by the patient's signal, and follows the same pattern in different individuals.

Dr. Ryerson objects to the abbreviated term hypalgesia for hypo-algesia. I have not liked this term, particularly when my stenographer spelled it "hipalgesia". However, hypalgesia is the accepted term according to the medical dictionary.

Dr. Steindler brought up a very important point of differentiation of true reflex sciatic pain from organic radiating or referred pain, which he has so excellently presented in his recent writings. However, the more one analyzes the early case histories of proved herniated discs, the more difficult it seems to distinguish the early low-back and irritative nerve-root symptoms from many other conditions, and the suspicion is growing in my mind that most of these low-back syndromes are related to disc pathology, and not to the many other conditions postulated by orthopaedic surgeons. I believe Dr. Steindler is in agreement with the statement that reflex pain cannot be used to explain sensory, reflex, or motor loss in an extremity; then there must be some organic pathology in that nerve or nerve root.

BRACKETT OPERATION FOR UNUNITED FRACTURE OF THE NECK OF THE FEMUR

A Report of Thirty-Four Cases

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The interest of the medical profession in fractures of the neck of the femur is amply attested by the tremendous bulk of literature which has accumulated on this subject, particularly in the past ten years. With the advent and development of methods of internal fixation, progress in the management of the fresh fracture has been swift and encouraging. A special committee sponsored by The American Academy of Orthopaedic Surgeons has recently completed a nation-wide survey on the treatment of the fresh fracture of the femoral neck, and has reported that good results are being obtained in about 70 per cent. of cases.[13] Campbell and Smith said that, under conditions in which early diagnosis and optimal treatment can be employed, the rate of non-union is about 10 per cent.

There remains, therefore, a sizable group of cases in which, for one reason or another, union fails to occur after fracture of the neck of the femur. The patients are usually totally disabled, with painful hips and instability sufficient to require the use of crutches.

Many procedures have been developed for the reclamation of these unfortunate patients. Comparatively few reports of statistically significant series of cases, in which the patients have been treated by the various operative methods, have appeared in the literature; consequently, evaluation of a given procedure is very difficult. According to Brackett, ". . . there is [now] need of special study and observation, particularly by the collection of end results, to aid in the application of these methods which we already have to the various types of cases, and to act as a guide in the choice of the method of treatment".

The dozens of operative procedures for the repair of non-union of the neck of the femur may be grouped into three general classes:

1. Osteosynthesis,
2. Osteotomy,
3. Reconstruction.

Each type of operation is limited in its application, and the intelligent selection of the optimal method in a given case is contingent upon an accurate estimation of the following cardinal points:

1. Age and general condition of the patient,
2. Time since the fracture,
3. Viability of the head of the femur,
4. Extent of absorption of the neck of the femur,
5. Presence or absence of arthritic changes in the acetabulum,
6. Degree of upward displacement and reducibility of the shaft.

Most authors are agreed that bone-grafting, or osteosynthesis, yields the best end results. The successful use of this procedure, however, demands a fairly young patient in good general condition, with early non-union, a viable head of the femur, and little or no absorption of the femoral neck. Since absorption of the femoral neck occurs with relative frequency and rapidity following fracture, few cases of non-union are seen which meet these prerequisites. Campbell and Smith have said that less than 10 per cent. of patients with non-union are suitable cases for osteosynthesis.

Osteotomy offers the simplest and safest procedure for the poor-risk patient, and gives a high percentage of satisfactory results. Cleveland, Hermann[9], Campbell and Smith, and others have expressed the opinion that osteotomy is the operation of choice in those cases which are not suitable for osteosynthesis. The general feeling at the Mayo Clinic is that, although the osteotomy is a useful and safe procedure, better mechanical function can be attained by the use of one of the reconstructive operations, in those cases in which the general condition of the patient does not prohibit a longer and more difficult operation.

Reconstruction is applicable in a large group of cases of non-union in which patients fail to meet the exacting requirements for bone-grafting operations, but whose general condition and potentialities for further usefulness warrant an attempt to secure maximal restoration and function. They may be divided into two sub-groups, according to whether the head of the femur is to be saved or sacrificed. In those cases of non-union in which the head is non-viable, the Whitman, Colonna, or Albee procedure is indicated. If the head is viable and the degree of absorption of the femoral neck rules out the use of a bone-grafting procedure, then the Brackett operation is indicated.

Originally described by Brackett and New in 1917, the operation requires thorough removal of all the dense and resistant fibrous tissue in the region of non-union. The proximal fragment, consisting usually of the articular portion of the head of the femur with a ragged collar of femoral neck, is trimmed back to fresh, bleeding bone, and the femoral surface of the head is then gouged out to form a kind of socket which later receives the freshened top of the femoral shaft. The remaining splinters of the femoral neck are trimmed back to the shaft on the distal fragment, the greater trochanter is cut off, and the freshened surface of the top of the shaft, the former site of the greater trochanter, is fitted into the previously prepared socket in the head fragment. The trochanter, with

FIG. 1-A

Moulage of ununited fracture of the neck of the femur.

FIG. 1-B

Moulage showing the anatomical changes of the Brackett operation. The end of the neck is probably more rounded at the time it is fitted into the head than is shown in the figure.

its attached muscles, is then anchored to the shaft one to two inches (2.5 to 5 centimeters) below its original site. This preserves nearly normal mechanical function of the musculature of the hip, and adapts the muscles to the new angulation of the femur (Figs. 1-A and 1-B).

One of the most difficult and yet most crucial steps in the operative procedure is the mobilization of the upper part of the femoral shaft. In cases in which non-union is of long duration, the upper part of the shaft has usually become adherent to the surrounding muscles of the hip. It is essential to the success of the procedure that good mobility be secured before the lower fragment is brought into apposition with the upper fragment.

A spica cast is applied to the toes on the affected side, and to the knee on the opposite side. This is bivalved at the end of five weeks, and passive movement and active exercises are begun. At the end of eight weeks after the operation, weight-bearing with crutches is commenced. The use of crutches usually is continued for one month.

In 1917, Brackett and New reported seven cases in which this operation produced good results. The first operation was done in 1911. After describing the procedure, they recommended its use in old fractures of the neck of the femur, at a period from some months to several years after the injury, when absorption of practically the entire neck has already occurred, and when the partially atrophied head of the femur consists only of the articular portion. They said that the operation is contra-indicated in the presence of hypertrophic changes in the acetabulum. In the seven cases in which follow-up data was obtained, the patients had firm union with strong weight-bearing, a limited, but practical, amount of motion, and the same amount of shortening which had existed before the operation.

Magnuson, in 1940, reported the end results obtained in fifty-nine consecutive cases of ununited fracture of the femoral neck, in forty-one of which he had used the Brackett operation with slight modifications. He advised that the viability of the head of the femur be judged at the operating table, without a definite preconceived idea as to whether

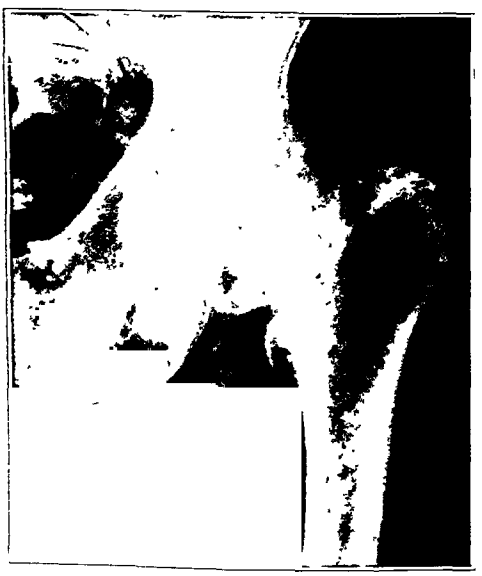

FIG. 2-A

Ununited fracture of the neck of the femur of a man, aged seventy-seven years. Non-union had been present for three and one-half months, and the femoral neck has been almost completely absorbed, but the head is viable and very little displacement has occurred.

FIG. 2-B

Appearance four months after Brackett operation and fixation with a vitallium screw. There is firm union of the fragments. The patient recovered almost normal hip function.

the Brackett or the Whitman operation should be used. His operative method consists of the introduction of either the remains of the femoral neck or the top of the shaft into the prepared head, fixation of the trochanter to the shaft with malleable iron or braided silk, and postoperative fixation by the Adams abduction plaster boot, each leg being abducted about 30 degrees. In twenty-eight of the forty-one cases in which the Brackett operation was employed, the patients obtained good results, with painless functioning hips, and were able to return to their former occupations. There were two deaths in the series. Poor results were obtained in six cases; the predominant cause of failure was that the shaft slipped out of the head with loss of weight-bearing stability.

Hermann [8] recently reported five cases in which the Magnuson modification of the Brackett operation was employed. The results were good in three of the cases and poor in two. He expressed the opinion that the procedure should be avoided in the treatment of non-united fractures of more than twelve months' duration.

Bickel and Ghormley in 1941 reported good results in two cases in which the Brackett operation had been employed.

The present report includes the two cases reported by Bickel and Ghormley in 1941, and summarizes the experience with the Brackett operation as used at the Clinic.

In a period of twenty-three years, from 1920 to 1942 inclusive, the Brackett operation has been performed in thirty-four cases by the consultants of the Section on Orthopaedic Surgery. The increasing popularity of the procedure at the Clinic is evidenced by the fact that seventeen, or half the total number of Brackett operations, have been done in the last four years. In 1942, alone, the operation has been used in nine cases.

Of the thirty-four patients, sixteen were males and eighteen were females. The average age at the time of operation was forty-seven and six-tenths years, with a range from seven to seventy-seven years. The average duration of the non-union at the time of operation was seventeen and six-tenths months; the shortest duration was three and five-tenths months; and the longest was forty-four months.

Since the operations have been performed by several orthopaedic surgeons, there have been minor modifications from case to case, particularly in the employment of various

FIG. 3-A

Ununited fracture of the neck of the femur in a man, aged thirty-two years. Non-union had been present for fourteen months. Bone-grafting was contra-indicated because of absorption of the femoral neck.

FIG. 3-B

Appearance four months after Brackett operation without fixation. Firm bony union has occurred between the femoral shaft and the head, and between the transplanted trochanter and the shaft. The patient returned to active duty as a Lieutenant in the Army.

means of internal fixation, but the basic mechanical principles of the Brackett procedure have been maintained. The operation was performed without the use of internal-fixation devices in thirteen cases. In eleven cases, a single vitallium screw was introduced through the transplanted trochanter, and was driven through the shaft and into the head fragment This represents the present method of choice in securing firm fixation of the fragments, when the Brackett operation is employed. It is significant that in the fourteen cases in which the operation was performed in the years 1941 and 1942, vitallium-screw fixation was used in eleven. In the remaining ten cases in which fixation was employed, beef-bone screws were used in four, steel nails in four, a beef-bone peg in one, and steel wire in one.

One death occurred in the series of thirty-four cases: the mortality rate, therefore, was 3 per cent. Death was attributed to staphylococcic bacteraemia secondary to wound infection, and the patient died six weeks postoperatively. The postoperative complications encountered in the series are listed in Table I.

TABLE I

POSTOPERATIVE COMPLICATIONS

Complication	No. of Cases
Wound infection	3
Mild shock	3
Decubitus	2
Pulmonary infarct	1
Thrombophlebitis	1
Psychosis	1
Total	11

In judging the end results, certain standards were arbitrarily adopted. Ability to walk without support of cane or crutches and possession of a practical range of painless motion of the hip were selected as the criteria of the good result. A practical range of motion of the hip was considered to be that range of motion which allowed the patient to carry on normal activity without restriction or encumbrance. The ability to tie the shoe on the foot of the affected leg and to climb stairs one foot ahead of the other in the normal manner were often used to determine the practical range of motion.

Ability to get about with the help of a cane, and with a slight degree of pain and limitation of motion of the hip, was considered a fair result. If the patient derived no benefit from the operation or was worse after the operation than before, the result was classed as poor

In the entire series of thirty-four cases, the results were classed as follows: good in twenty-three, or 67 7 per cent ; fair in five, or 14.7 per cent ; and failure in six, or 17 6 per cent (including the one death).

An evaluation of the various modifications of the Brackett operation can be reached by splitting the series into groups, according to the means of internal fixation used, and calculating the end results for each group Table II shows that the best results were obtained in cases in which a vitallium screw was used (In one case a steel wire was used to attach the transplanted trochanter to the shaft of the femur. A beef-bone peg was used in one of the first cases in which fixation was employed.)

An analysis of the six failures in the group revealed that the cause of failure in four cases was slipping of the fragments, usually the head from the shaft, after good position had been obtained at operation Infection accounted for the remaining two failures It is interesting that four of the six poor results occurred in cases in which a nail had been used for fixation

FIG. 4-A

Ununited fracture of the neck of the femur of a girl, aged seven years. Non-union had been present for eighteen months. There was almost complete absorption of the femoral neck.

FIG. 4-B

Appearance six months after Brackett operation and fixation with a vitallium screw. Bony union has occurred between the femoral shaft and the head, and between the transplanted trochanter and the shaft.

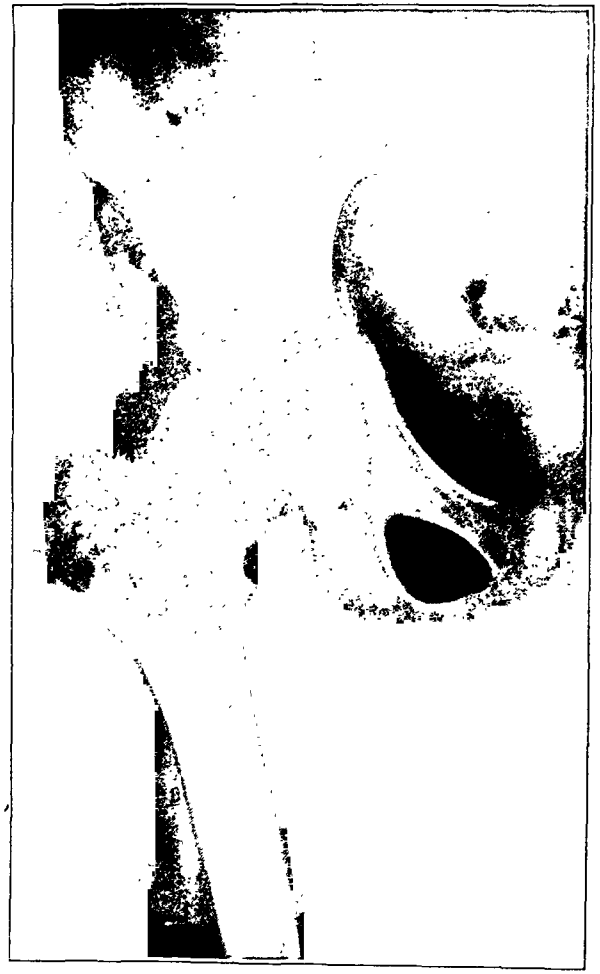

FIG. 4-C

End result, six months after removal of vitallium screw. Motion of the hip is normal and the patient is able to walk or run without a limp.

TABLE II

END RESULTS

Means of Internal Fixation	No. of Cases	Results		
		Good	Fair	Poor
Vitallium screw	11	10	0	1
No internal fixation	13	9	3	1
Steel nail	4	0	0	4
Beef-bone screws	4	3	1	0
Steel wire	1	0	1	0
Beef-bone peg	1	1	0	0
Total	34	23	5	6

Figures 2-A, 2-B, 3-A, 3-B, 4-A, 4-B, and 4-C show the results obtained with the Brackett operation in cases of fracture of the femoral neck, in which the ages of the patients varied widely.

COMMENT

Non-union of fractures of the femoral neck has been a surgical problem for years. The authors believe that in past years there have been many cases in which the patients might have been permitted a more useful existence. Even with the improved methods now obtained by internal fixation, a number of patients are relegated to a life on crutches or in a wheel chair without some sort of restoration of union between the shaft and the femoral head.

Reich, Jahss and Mintz, and Speed and Smith have recently reported results obtained with various types of osteotomy in ununited fractures of the femoral neck. Reich's results were satisfactory in twenty-two of twenty-six cases, and union occurred in each of the twenty-two cases. Jahss and Mintz obtained satisfactory results in fourteen of sixteen cases, but in only five cases was bony union obtained. Speed and Smith obtained good or fair results in 80 per cent. of the thirty cases, although bony union occurred in only 25 per cent. of the cases.

From experience with the Brackett operation at this Clinic, it would seem that good results may be obtained in more than 90 per cent. of cases in which the operation is carefully done and the fragments are adequately transfixed at the time of operation. Magnuson found that the predominant cause of failure was a slipping of the shaft from the head, and in our series this proved to be the most frequent cause of failure. The operation is not so simple as osteotomy, yet in our group of cases the incidence of shock and mortality has been low. It is felt that the reconstruction gives a much better anatomical restoration of the relationship of the head and trochanter to the shaft. In many instances there has been no limp, and no residual disability has occurred. Mobilization of the head of the femur, should it be incarcerated in the acetabulum, may help to improve the articular function. If the articular surface has been destroyed and if the femoral head has become ankylosed to the acetabular surface, the operation should not be attempted.

SUMMARY AND CONCLUSIONS

1. There is need for careful collection and study of end results obtained with the various operative procedures designed for the reclamation of the ununited fracture of the femoral neck, in order that the operations may be evaluated and employed in suitable cases.

2. At the Clinic, the Brackett operation was used in thirty-four cases of non-union of a fracture of the femoral neck in the years 1920 to 1942, inclusive. Good results were obtained in twenty-three, or 67.7 per cent. of the cases.

3. A method of internal fixation by which a vitallium screw is introduced through the transplanted trochanter and is driven through the shaft and into the head fragment has been used in eleven cases in the past two years. Good results have been obtained in ten of the eleven cases.

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THE SIGNIFICANCE OF THE ILIOCOSTAL FASCIAL GRAFT IN THE TREATMENT OF PARALYTIC DEFORMITIES OF THE TRUNK*†

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Just as the paralysis of the everting or inverting muscles of the foot results in a characteristic deformity, so the paralysis of groups of trunk muscles results in a definite deformity of the trunk. This deformity is a contracture in exactly the same sense as a paralytic club foot. Though our knowledge of the kinesiology of trunk muscles is still far from exact, a study of thirty-eight poliomyelitic cases with paralysis of the trunk muscles has led to the tabulation of three groups of paralytic deformities.

In the first, there is a unilateral paralysis of the external and internal oblique abdominal muscles and of the quadratus lumborum of the same side (Figs. 1, 2, 8-A, 10-A, and 11-A). This results in a lumbothoracic scoliosis, convex toward the paralyzed side, and in a downward tilt of the pelvis on the same side: the pelvis, in turn, becomes fixed in this position,—the so-called fixed paralytic pelvic obliquity, previously described by the author.

In the second group, the internal and external oblique muscles of one side are involved, but the quadratus lumborum is not paralyzed (Figs. 3, 4, and 12-A). There develops a lumbothoracic scoliosis, convex toward the paralyzed side, as in the first group, but the intact quadratus prevents a downward tilt of the pelvis, and, consequently, the fixed obliquity characteristic of the first group does not occur.

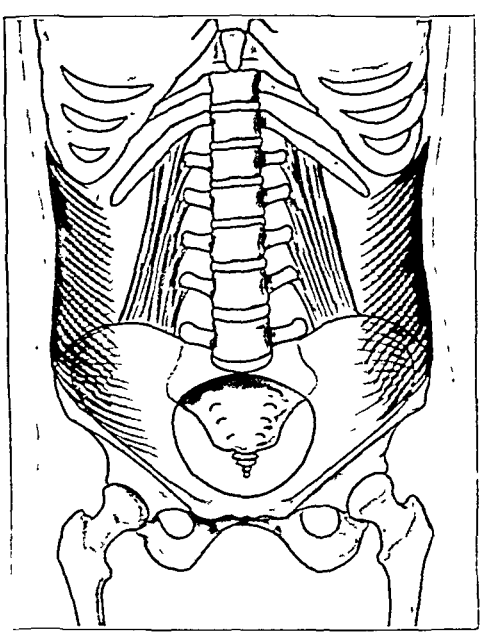

FIG. 1

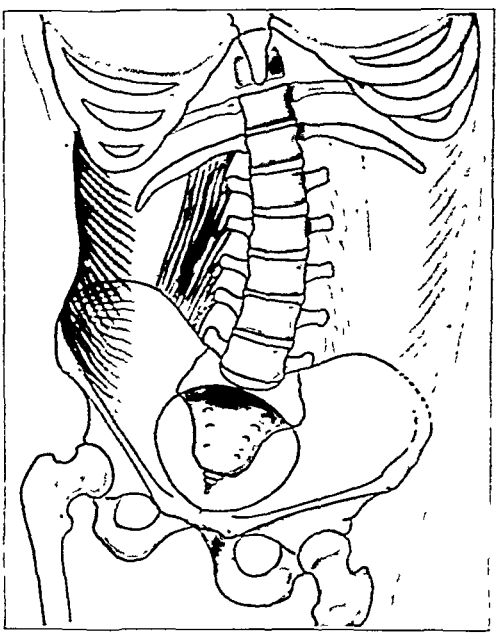

FIG. 2

Fig. 1: Diagrammatic drawing illustrating the relation of the lateral abdominal muscles and of the quadratus lumborum to the pelvis.

Fig. 2: This illustrates the effect of a unilateral paralysis of the lateral abdominals and the quadratus lumborum of the left side. The unopposed strong muscles of the right side pull up the right side of the pelvis, the left side tilts downward, and a left convex lumbothoracic curve develops. If uncorrected, the deformity becomes fixed. This represents the deformity seen in patients in Group I.

* Read at the Annual Meeting of The American Orthopaedic Association, Cleveland, Ohio, June 7, 1943.

† Aided by a grant from The National Foundation for Infantile Paralysis, Inc.

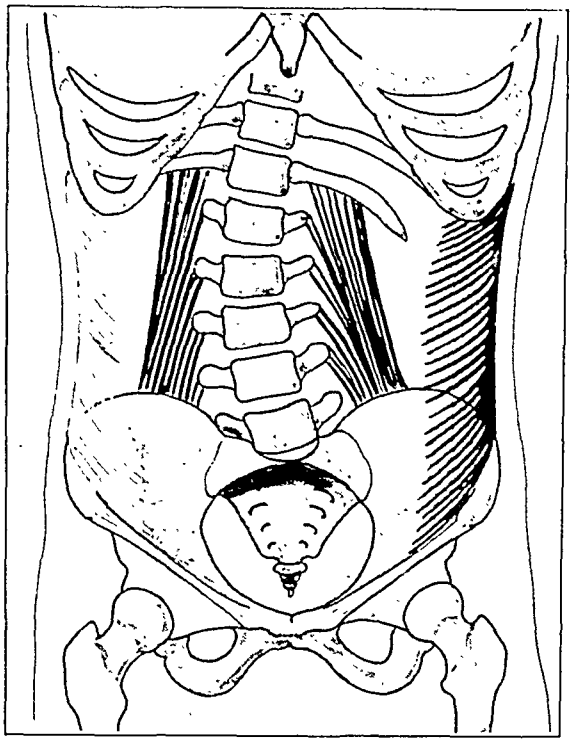

FIG. 3

This diagram illustrates the patients of Group II. In these, there is a unilateral paralysis of the lateral abdominals, but the quadratus lumborum is not affected. A scoliosis develops, with the convexity to the paralyzed side, but little or no pelvic tilting occurs.

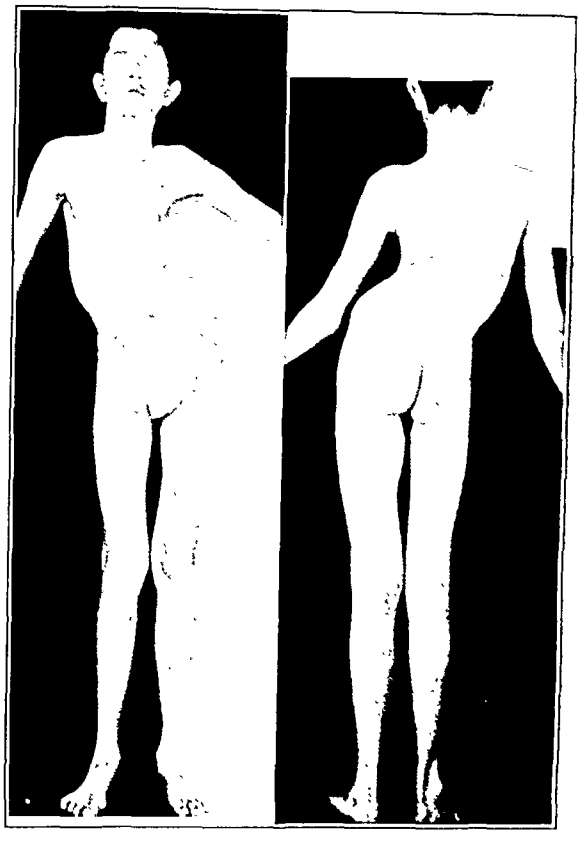

FIG. 4

Photograph of a patient (T. B.) of the second group shows that, despite the marked scoliotic deformity, there has been no tilting of the pelvis because of the powerful action of the quadratus lumborum. (This patient is still under treatment and has not been included in this series of case reports.)

Finally, in the third group, there is a bilateral paralysis of the recti abdominis with bilateral weakness of the external and internal oblique and transverse muscles. As a result, the pelvis, when seen in sagittal section, tilts forward (Figs. 5, 6, 13-A, and 14-A), so that the plane of the pelvic inlet forms an angle of 60 degrees or more, instead of the normal angle of 30 degrees; the abdominal wall sags markedly; the lumbar lordosis is much increased; and the sacrum assumes a more nearly horizontal position.

Reference to Figures 1 to 6, illustrating these three types of trunk deformity, will clarify the kinesiological principles underlying their development. There is of course considerable overlapping of the three groups, and, in a few instances, it has been necessary to grade the individual case as belonging to two groups. The sacrospinalis and the other spinal muscles unquestionably play a rôle in paralytic trunk deformities, but with our present all too crude methods of muscle testing, the author has been unable to reach definite conclusions about their significance. With further refinements of technique, possibly through the use of chronaxies and action currents, it is to be hoped that an accurate estimate may be reached of their place in the complex kinesiological puzzle. A slight advance has already been made by the research of Greenberg and the author. They have been able to show, by the determination of trunk-muscle strength of 500 normal individuals tested on the swivel table, that there is a definite ratio of three to four to six between the strength of the flexors of the trunk, the lateral muscles, and the extensors. Any variation from this ratio indicates an abnormality which, if uncorrected, may eventually lead to a permanent deformity.

Despite the inherent difficulties, it is possible to recognize weakness of the trunk muscles at an early period following the attack of infantile paralysis. It is of the utmost importance to do this, since early recognition makes complete correction possible, whereas

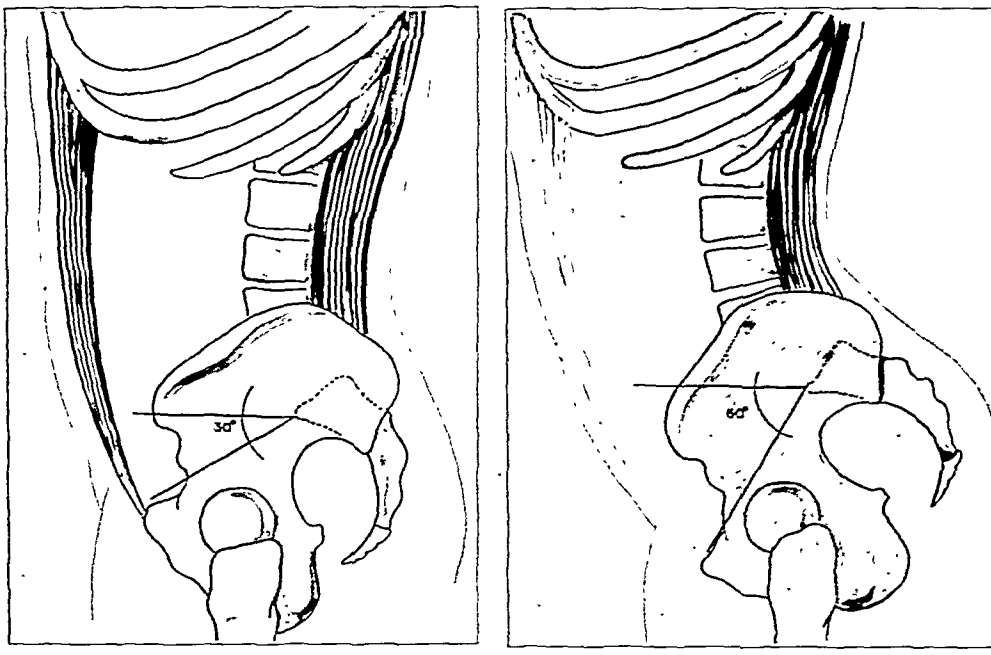

Fig. 5: A sagittal diagrammatic drawing to illustrate the effect of the anterior abdominal muscles and the spinal musculature in maintaining normal inclination of the pelvis.

Fig. 6: This drawing illustrates the effect of paralysis of the abdominal muscles. The unopposed muscles of the spine tilt the pelvis forward, thus markedly increasing the lordosis. The abdomen sags, and the sacrum becomes more horizontal than the normal.

long delay leads to the development of deformities which may defy the "tears, toil, blood, and sweat" of patient as well as of surgeon. Tests have already been published, by Lowman in 1932 and by the author in 1936. Of particular value are the lateral swinging tests and the blowing test for the lateral abdominals, and the pelvic-elevation test for the quadratus lumborum.[3] Surgeons should familiarize themselves with these tests, and should use them routinely as part of the examination of poliomyelitic patients. Since these tests are largely subjective, they should be supplemented whenever possible by exact measurements on the swivel table.

The analogy between the paralytic deformities of the foot and of the trunk can be extended to their therapy. Just as minor grades of equinovarus can be corrected by suitable bloodless methods, so minor grades of trunk deformity, usually detected in the early stages of their development, may be corrected by non-operative procedures. These involve the well-established principle of stretching the tight or contracted muscles, so as to allow the relaxed, weaker muscles an opportunity to regain their normal resting length. This can be done by the push-and-pull apparatus[2, 3] which exerts traction on the high side of the pelvis and an upward push on the low side. The Roger Anderson well-leg traction splint can be utilized for the same purpose. In some patients, where the deformity is somewhat greater, skeletal traction through the Kirschner wire is effective in pulling down the high side of the pelvis. The scoliosis can frequently be corrected by the turnbuckle plaster, used by itself in the second group of cases, or in conjunction with the Roger Anderson apparatus in the first group, where fixed pelvic obliquity complicates the scoliosis (Fig. 7). The sagging abdomen and the anterior tilting of the pelvis, seen in the third group, can be combatted by suspension in a hammock or by suitable tilting of the Gatch bed, so as to relax the weakened anterior abdominal muscles.

These non-operative measures may suffice in some cases, but, in most of the patients who have come under the author's care, they have not given permanent correction. The inequality in muscle strength persisted, and led to a recurrence of the deformity as soon as

the corrective forces were removed. It was evident that some more radical procedure was necessary to retain trunk equilibrium, just exactly as a paralytic club foot, temporarily corrected by manipulation and retention in plaster-of-Paris, requires operative procedures for its permanent cure. In the first years of the author's study of these trunk paralyses, it seemed probable that once the deformity was corrected, fusion of the spine would give permanence to the result. This operation, however, failed, as evidenced by the following case.*

I. K., when admitted to the Hospital for Joint Diseases in 1929, showed a severe trunk deformity of the first group (Fig. 8-A). The right side of the pelvis was four inches lower than the left. There was a corresponding severe right lumbothoracic curve with almost complete paralysis of the right lateral abdominal muscles and the right quadratus lumborum. After many technical difficulties had been overcome, the pelvic obliquity was corrected, and the spine deformity was much improved by a series of turnbuckle plaster-of-Paris spicas, combined with push-and-pull devices. A spine fusion in two stages was then done, extending from the fourth lumbar to the ninth thoracic vertebra.

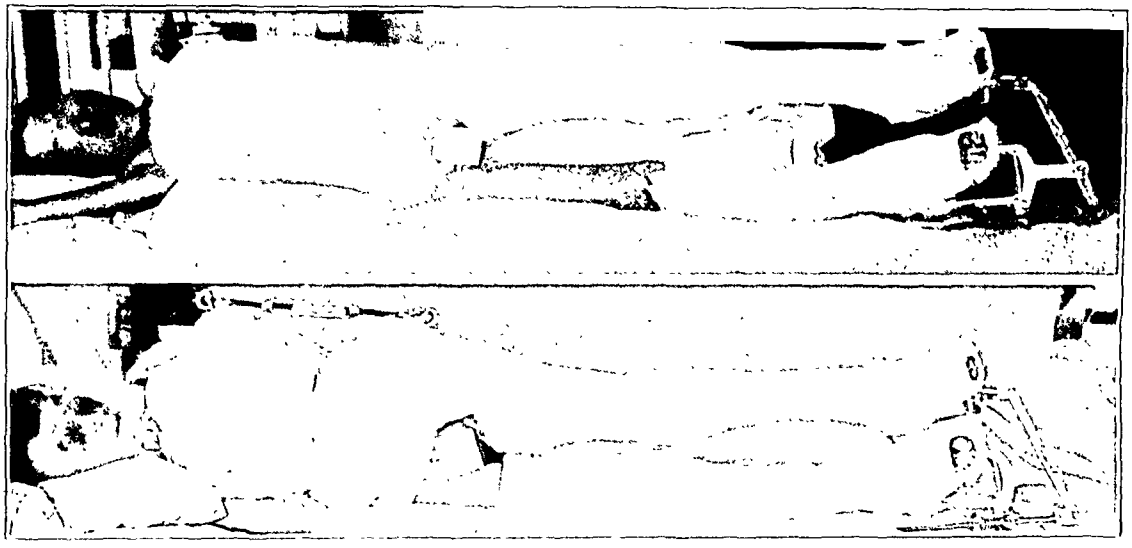

FIG. 7

These two photographs show the application of the Roger Anderson well-leg splint to a patient with a right lumbothoracic curve and a fixed paralytic pelvic obliquity, with the right side of the pelvis three inches lower than the left. The lower photograph shows the insertion of the turnbuckle. (*Reproduced from The Journal of Bone and Joint Surgery, XVIII, 96, January 1936.*)

The immediate result was so good that a photograph of the patient was shown at the 1930 meeting of The American Orthopaedic Association (Fig. 8-B), but the correction was not permanent. Three years later, when the patient returned for a follow-up examination, the deformity had recurred (Fig. 8-C).

At first it was thought that this was due to a failure of the spine fusion, but this explanation was not confirmed by careful roentgenographic tests. On further study, it became evident that the recurrence was due to the imbalance of the trunk muscles; the paralyzed right abdominals and the quadratus lumborum could not hold up their side of the pelvis when matched against the relatively strong left abdominal muscles. To correct the deformity was obviously now more difficult than at the first admission, since the spine was now fused in a pathological position. The only method of correction which the author could devise was to create a pseudarthrosis in the fused area of the spine. This was accomplished, though with difficulty, owing to the prolific bone formation following the fusion. Great care was necessary not to damage the dura which was exposed for a distance of one and one-half inches. This operation permitted reapplication of the turnbuckle plaster with satisfactory correction of the pelvic obliquity, although some spine deformity persisted. The problem then was how to restore the balance of the trunk mus-

* This case has already been referred to in the article published in *The Journal of Bone and Joint Surgery, (XIII, 11, January 1931).*

FIG. 8-A

FIG. 8-B

FIG. 8-C

Fig. 8-A: I. K. at the time of his first admission in 1929. The severe pelvic obliquity is caused not by a contracture of the abductors of the right hip, but entirely by the paralysis of the right abdominal muscles and the right quadratus lumborum. The patient belongs to Group I. (*Reproduced from The Journal of Bone and Joint Surgery, XIII, 11, January 1931.*)

Fig. 8-B: Eight months later, the pelvic deformity has been corrected by push-and-pull devices, and the scoliosis, by means of a turnbuckle plaster-of-Paris corset. A fusion operation has been done, extending from the ninth thoracic to the fourth lumbar vertebra. (*Reproduced from The Journal of Bone and Joint Surgery, XIII, 11, January 1931.*)

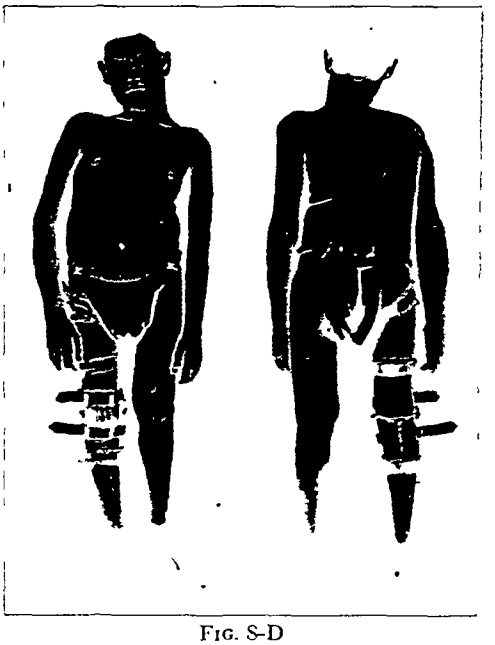

FIG. 8-D

Fig. 8-C: At the time of readmission in 1934, there had been a return of the pelvic obliquity, not because of failure of the spine fusion, but because of the persistence of the imbalance of the trunk muscles.

Fig. 8-D: Ten months later, after correction by means of a spine operation to create a pseudarthrosis of the fused spine, repetition of the push-and-pull correction, and insertion of a strong iliocostal fascial graft to reinforce the paralyzed right abdominal muscles. The pelvic obliquity has been corrected, but some deformity of the spine persists. There has been no recurrence of the pelvic obliquity during a nine-year follow-up period. The patient works in a bank and walks with only a slight limp.

cles. Unfortunately, a muscle-tendon transplant, as in a paralytic club foot, was not feasible, but Lowman's operation of a fascial transplant seemed an excellent substitute.

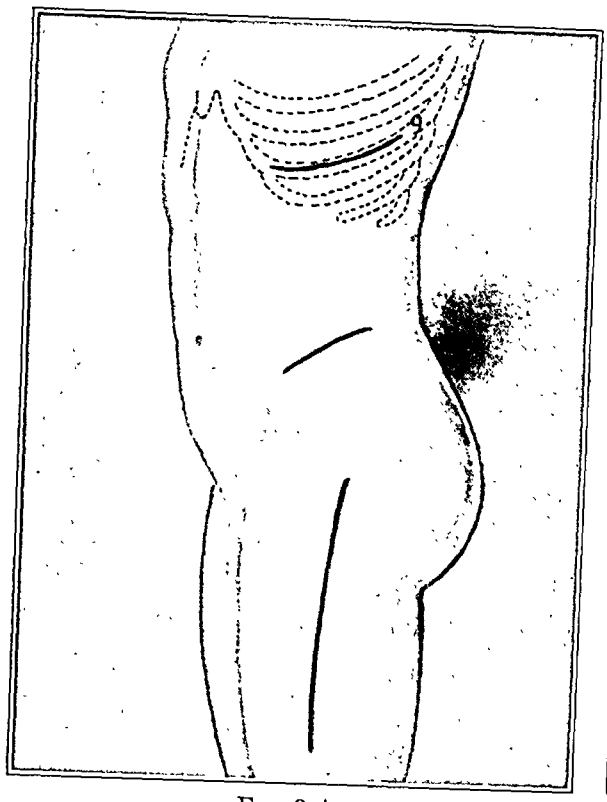

FIG. 9-A

The three incisions for the removal and insertion of the fascial graft.

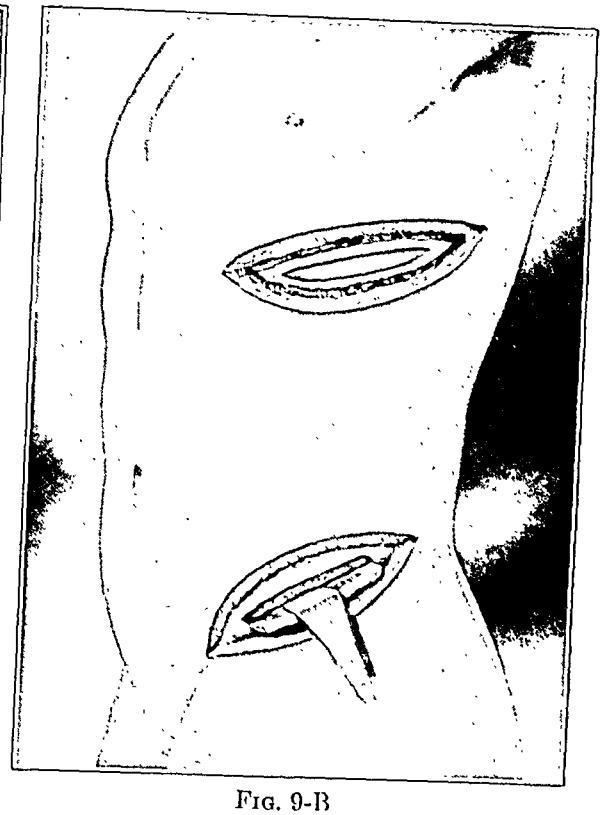

FIG. 9-B

Exposure of the ninth rib and the iliac crest.

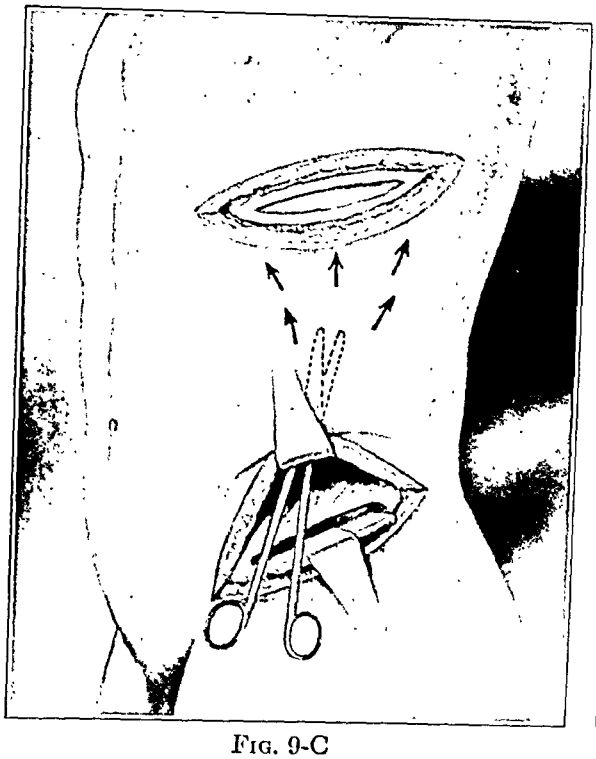

FIG. 9-C

Construction of the tunnel connecting the iliac crest and the ninth rib. The tunnel must be at least three inches wide.

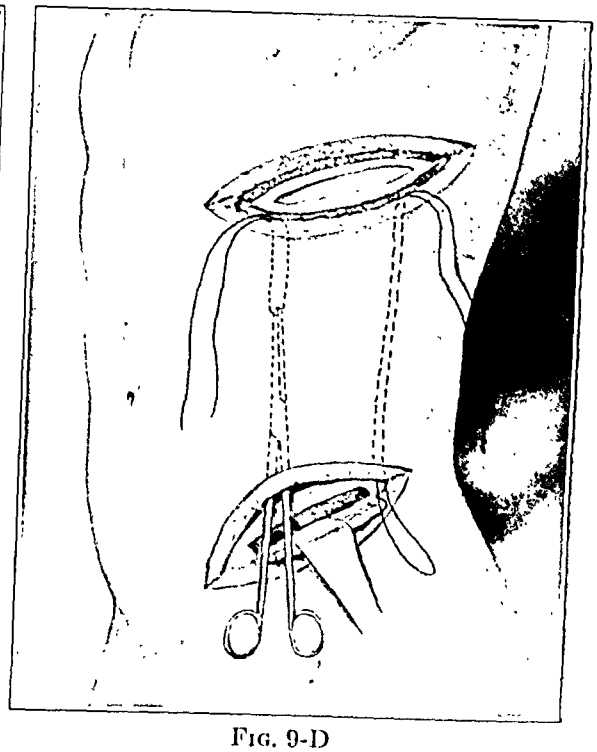

FIG. 9-D

Passage of the guide sutures through the tunnel.

The technique of the operation, however, required modification, since only by running the fascia from bone to bone could the full strength of the fascia be utilized to hold up the low side of the pelvis.* The effectiveness of this procedure has been proved by the maintenance of normal pelvic position during a period of many years.

* In Lowman's technique, he ran the fascial strips from rib or pelvis to the umbilicus.

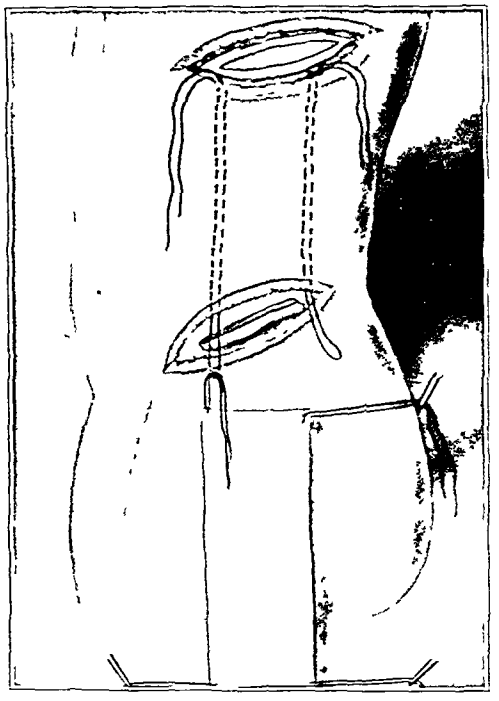

FIG. 9-E

The fascial sheet is about to be drawn through the tunnel by means of the guide sutures.

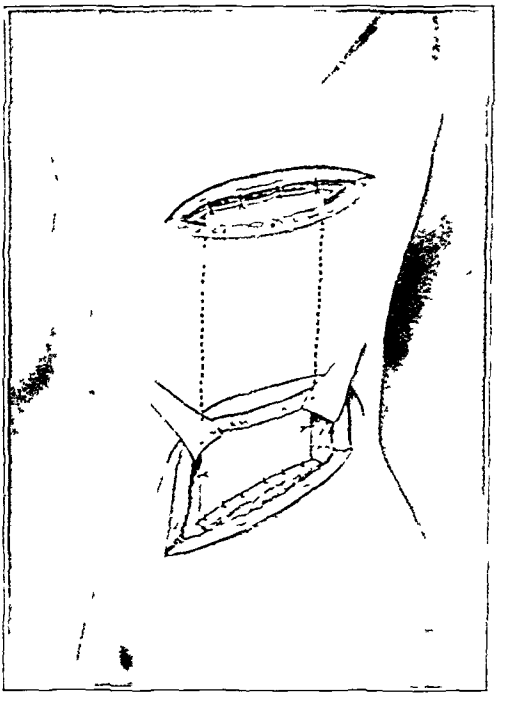

FIG 9-F

The fascial sheet has been fastened under tension to the iliac crest and the ninth rib The lateral sutures taken in the abdominal musculature hold the fascia flat and prevent it from rolling.

The following operative method was worked out at that time, and has been used with only slight changes ever since. An incision four and one-half inches long is made in the course of the ninth rib on the paralyzed side (Fig. 9-A), running forward and downward from the anterior axillary line. The rib is exposed for three and one-half inches just lateral to the chondral cartilage (Fig. 9-B). The periosteum is incised in the same line as the skin incision, and is lifted away from the rib to form a long flap attached to the upper margin of the rib At each end of this flap, a guide suture is taken to help in anchoring the fascial graft

The second incision, four and one-half inches long, runs along the iliac crest and the outer portion of Poupart's ligament (Fig. 9-A). The outer lip of the iliac crest, with the fascia lata still attached, is split off with a chisel (Fig. 9-B). A guide suture is passed at each end of the bone incision. This stitch passes around the outer iliac lip, which has been chiseled off, and emerges through the fascia. Its purpose is to draw the fascial transplant between the iliac crest and the displaced lip, where it will contact roughened bone on both sides.

A broad tunnel is then constructed, connecting the ninth rib and the iliac crest. This must lie in the plane just anterior to the deep abdominal fascia, and it must be as wide as the exposed rib. It is best made by alternately snipping the fatty subcutaneous tissue anterior to the fascia with scissors and then spreading the blades apart (Fig. 9-C). Let it be emphasized that the tunnel must be wide enough to permit a broad strip of transplanted fascia to lie flat. By using long retractors, such as those devised by Hibbs for the spine fusion, the subcutaneous fat can be lifted up, first from one incision and then from the other, and all bleeding points caught. A long loop of strong silk is then passed through the medial portion of the tunnel and a second loop through the lateral (Fig. 9-D). The free ends of the silk emerge above, the loops emerge below near the iliac crest. They are to serve later to draw the transplant through the tunnel.

The third incision is made vertically down the outer aspect of the thigh of either the paralyzed side or the opposite (Fig. 9-A). Its length should be three inches greater than the distance between the ninth rib and the anterior superior iliac spine. A strip of fascia lata, at least three inches wide and one inch longer than the distance between rib and anterior superior spine, is excised. An atraumatic technique is advisable. The fascia should be caught at each corner with a stitch which acts as a convenient handle and which also enables the operator to draw the fascia gently through the abdominal tunnel. This is done by placing the two proximal fascial stitches in the loops of silk running through the abdominal tunnel (Fig. 9-E). The fascia must not be allowed to twist, but must lie flat against the anterior abdominal wall. When placed in satisfactory position, it is fastened by a series of stitches, first to the iliac crest, then to the periosteum of the ninth rib. The suture material may be left to the choice of the individual operator (the author has used No. 1 forty-day chromic gut), but it is important to get firm fixation by passing each stitch in the iliac wound around the outer iliac lip and then through the fascia lata, and each stitch of the rib wound through the periosteum close to the rib and out through the intercostal muscles and fascia. The iliac stitches are taken first, and they are reinforced by a second row passing through the fascia lata of the thigh and the fascial graft. Lateral stitches are taken on each side of the graft, holding it flat against the anterior abdominal muscles (Fig. 9-F). By lifting the anterior wall of the tunnel with retractors, it is possible to take three such stitches on each side, placing them about three-quarters of an inch apart. When the fascia has been securely fastened below, it is drawn upward against the rib with sufficient force to make it tense. If the thigh on the paralyzed side is free, an assistant pushes the pelvis up so as to approximate the distance between rib and crest. In the author's first cases, he passed the upper portion of the fascia around the ninth rib, but, in a number of young children, this tore the rib away from the cartilage. He has, therefore, abandoned

FIG. 10-A

FIG. 10-B

Fig. 10-A: L. B., aged nine, is characteristic of Group I. There is a left pelvic obliquity, due to paralysis of the left lateral abdominal and quadratus lumborum, with a corresponding severe left lumbothoracic scoliosis. The left leg is apparently four and one-half inches longer than the right. The deformity was of four years' duration and had been uninfluenced by conservative treatment in one of the leading orthopaedic hospitals. The patient was unable to stand, even when supported.

Fig. 10-B: Roentgenogram at time of her admission.

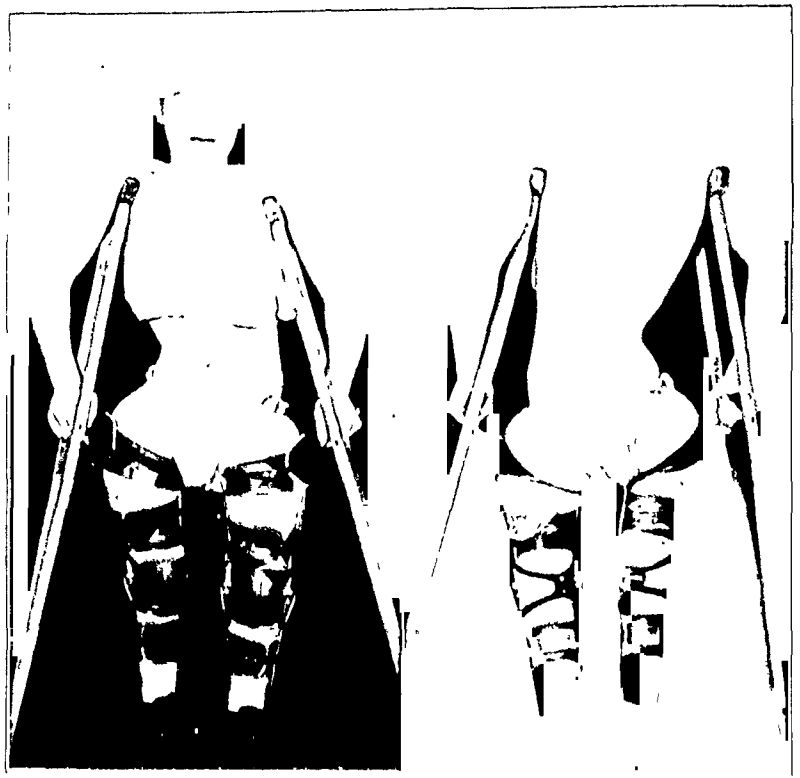

FIG. 10-C

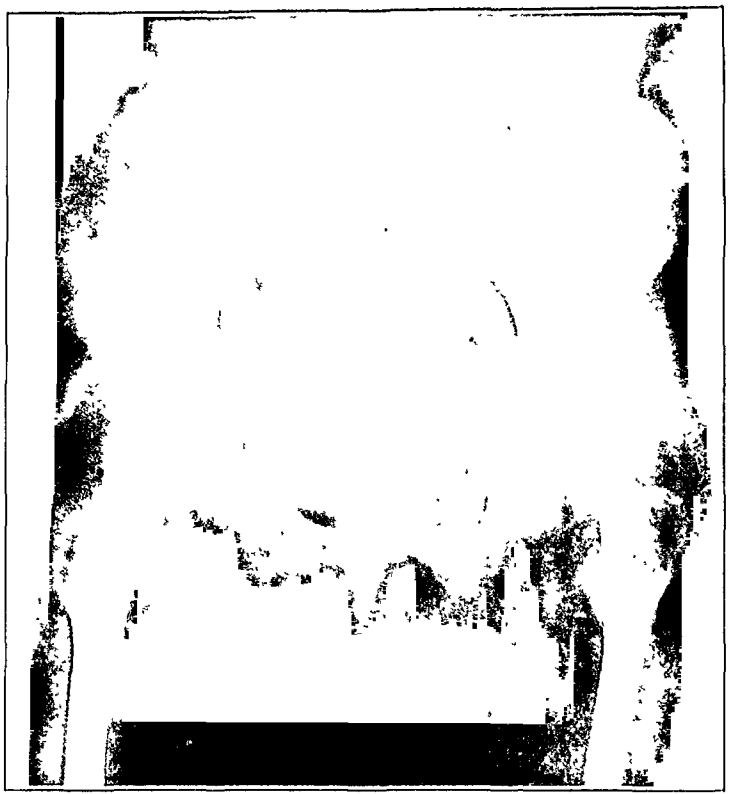

FIG. 10-D

Fig. 10-C: Five years subsequent to correction of fixed paralytic pelvic obliquity by means of (a) operative division of the tight ligaments of the lumbar spine and the contracted right quadratus lumborum, (b) release of the abduction contracture of left hip, (c) traction to the short right leg and upward push on the long left leg, (d) turnbuckle jacket for the scoliotic spine, (e) reinforcement of the paralyzed left abdominal muscles and quadratus lumborum by means of a fascia lata transplant running from the crest of the left ilium to the ninth rib.

The patient is able to walk seven or eight blocks and attends high school.

Fig. 10-D: Roentgenogram five years after correction of the fixed paralytic pelvic obliquity. This patient was classified as having a good result. The result could not be classed as excellent, because of the persistence of a considerable scoliotic deformity.

FIG. 11-A

FIG. 11-B

Fig. 11-A: R. R., aged eighteen, at time of admission to the Hospital. This patient belongs to Group I. The fixed paralytic pelvic obliquity is due to paralysis of the right lateral abdominal muscles and quadratus lumborum. The right leg is apparently three inches longer than the left, and, because of this and weakness of the knee muscles, a severe genu recurvatum has developed. The patient was able to stand only for a few minutes. She could walk only two or three steps. (*Reproduced from The Journal of Bone and Joint Surgery, XVIII, 94, January 1936.*)

Fig. 11-B: Roentgenogram taken at time of her admission. Note the subluxated position of the left hip which is usually present in patients of this type. (*Reproduced from The Journal of Bone and Joint Surgery, XVIII, 94, January 1936.*)

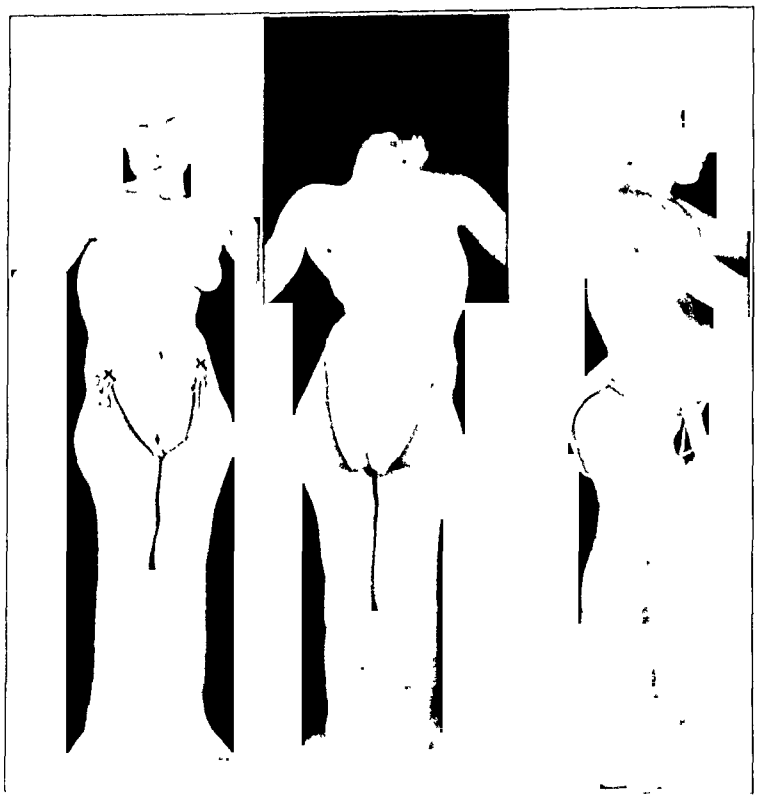

FIG. 11-C

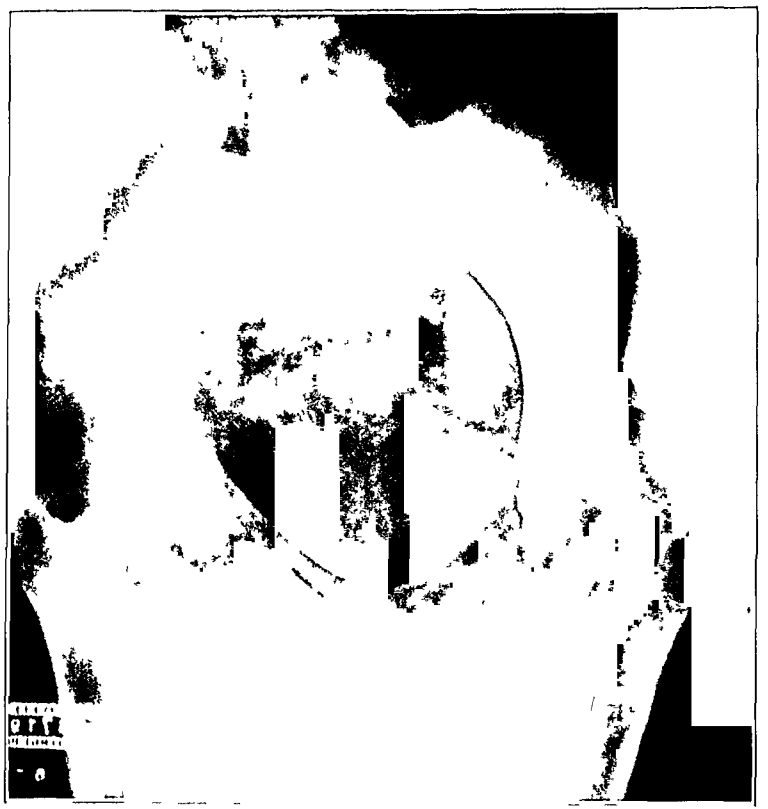

FIG. 11-D

Fig. 11-C: Two years following correction of the deformity and the genu recurvatum. The methods used were similar to those employed in the case of L. B., and, in addition, a bone-block operation was done on the right knee. The patient has married and attends to all her own housework. (*Reproduced from The Journal of Bone and Joint Surgery, XVIII, 95, January 1936.*)

Fig. 11-D: Roentgenogram following correction of the pelvic obliquity. This patient was classed as having a good result. (*Reproduced from The Journal of Bone and Joint Surgery, XVIII, 95, January 1936.*)

TABLE I
RESULTS OF OPERATION IN THIRTY-EIGHT CASES

Group	No. of Cases	Results		
		Excellent	Good	Fair
Group I	22	4	14	4
Group II	3	0	2	1
Group III	8	1	6	1
Combination of Groups I, II, and III	5	0	3	2
Total	38	5	25	8

this method, and has secured a satisfactory anchorage by passing the fixation stitches through the periosteum and the muscles just above it. If properly placed, these stitches bring the fascial transplant against the roughened surface of the rib, where bony union is practically certain.

This type of fascial suspension has been carried out in thirty-eight cases, in eight of which—namely, those of the third group—the transplant was bilateral. In all forty-six operations, the fascia healed in successfully, although in five patients there was a wound infection. This invariably involved the iliac wound, and, as it occurred exclusively in young children, it was believed due to urinary infection. By elevating the head of the bed and changing the iliac dressing promptly if there was a suspicion of soiling by urine, the percentage of infections during the past five years has been cut to zero. Occasionally there have been slight modifications of the operation. In the bilateral cases, where the entire abdominal wall requires support, the fascial grafts are attached to the outer half of Poupart's ligament, as well as to the iliac crest. The grafts in these cases are at least four inches wide, and the upper half is slit longitudinally so as to form two tails. The medial tail is attached as closely as possible to the ensiform cartilage, and to the cartilage of the ninth rib; the lateral tail, to the rib itself. In one case, owing to inadequate fascia lata, the fascial graft was taken from the lumbar region; in two others, a homoplastic graft was taken from a relative of the child; and in a third, the graft was reinforced by a strip of nylon. Healing

FIG. 12-A

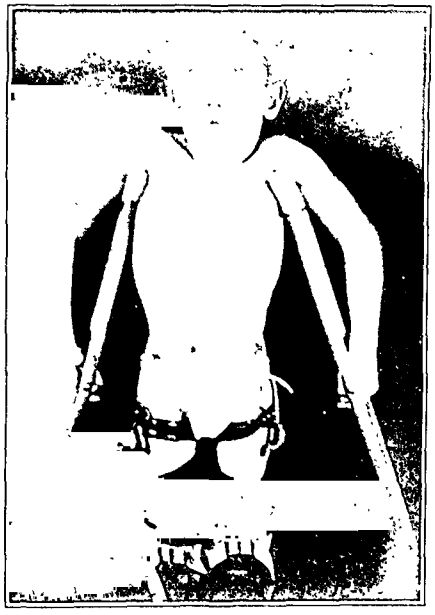

FIG. 12-B

Fig. 12-A: G. J. is an example of Group II, characterized by unilateral paralysis of the abdominal muscles with intact quadratus lumborum. Note the bulging of the left abdominal muscles, which could not be overcome by voluntary effort. There is no pelvic obliquity. This patient also showed a moderate left lumbothoracic scoliosis.

Fig. 12-B: One year after insertion of fascial graft to reinforce the paralyzed left abdominal muscle, the sagging of the left side of the abdomen has been completely corrected.

occurred in all four, but these modifications should be reserved for the unusual cases in which autoplastic fascia lata is not available. In two patients operated upon by another Service of the Hospital for Joint Diseases, and not included in this report, prepared beef fascia was used. In these, the grafts completely disappeared in one year's time, and the pelvic deformity promptly recurred.

Clinically, the results of the autoplastic fascial transplant have been gratifying. The fascia hypertrophies with use, and after a year or two can be felt as a strong band, usually about one inch wide, running from the rib to the iliac crest. The patient lifts the pelvis by elevating the ribs of the paralyzed side. The fascia evidently grows with the patient, for, in cases followed from early childhood to late adolescence, there has been a measurable lengthening of the fascial strip as the distance from rib to iliac crest has increased. In all patients there has been marked improvement in walking and in posture, and a corresponding improvement in general condition.

One of the problems for which, as yet, a definite answer cannot be given is when to combine spine fusion with the fascial graft. As has already been shown, the spine fusion by itself cannot prevent recurrence of the deformity when there is a marked imbalance of the trunk musculature. There are, however, some patients in whom the result of the fascial graft is improved by the spine operation. This applies particularly to Group III, where the fusion is usually a necessary adjuvant. In the small Group II it was necessary in two cases, and in the large Group I it was rarely necessary. A workable rule-of-thumb is to perform the fascial operation first, observe the patient for a period of six months, taking roentgenograms in a standing position at three-month intervals, and if the scoliotic curve increases 10 degrees, then perform the fusion.

The table of results (Table I) may seem disappointing to some, because of the small percentage of excellent results. This is due, first, to the rigid criteria which have been set up; second, to the fact that so many of the patients came with severe deformities, and were unable to stand because of a pelvic obliquity and a severe spinal curvature (Figs. 10-A and 11-A). Even after adequate correction of the obliquity, so much spine deformity persisted that the result could not be classed as excellent. This category includes only those patients for whom the diagnosis was made before the spine deformity had become rigid, and in whom, consequently, complete correction could be

FIG. 13-A

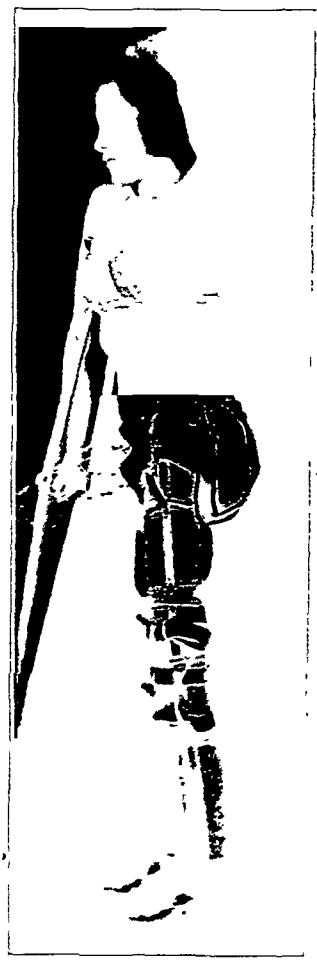

FIG. 13-B

Fig. 13-A: M. R., at the age of seven. This patient belongs to Group III, characterized by bilateral abdominal paralysis, forward tilting of the pelvis, increased lordosis, and a horizontal sacrum.

Fig. 13-B: M. R., at the age of sixteen, nine years subsequent to the bilateral implantation of fascial grafts running from Poupart's ligament and the iliac crest to the ensiform cartilage and the ninth rib. The sagging abdomen and the increased lordosis have been completely corrected. The patient has a mild lumbothoracic scoliosis which is well compensated and does not interfere with her activities. This result was classed as excellent.

FIG. 14-A

FIG. 14-B

Fig. 14-A: L. H. at the age of eight. This patient has bilateral weakness of the abdominal muscles, characteristic of Group III, with a sagging abdomen and increased lordosis.

Fig. 14-B: This shows the result following the bilateral implantation of iliocostal fascial graft. This result was classed as fair, because of the persistence of some sagging of the abdominal wall.

secured, and the result maintained for a minimum of a five-year observation period. The poor results were in older individuals, in whom, despite all efforts, it was impossible to straighten the pelvis, or when, after correction, the deformity returned because of muscle imbalance.

In long-standing cases, the contraction of trunk muscles and spinal ligaments is so marked that even skeletal traction is insufficient to overcome the deformity. In this group, preliminary operations are advisable to release the tight structures. An incision is made, running from the ninth thoracic vertebra to the sacrum. The tissues are stripped from the spine as in the first stage of the Hibbs' spine fusion. Then every accessible ligament is cut,—the interspinous, the ligamenta flava, and those that envelop the intervertebral joints. The fascia and the sacrospinalis on the concave side of the curve, if contracted, are divided transversely. Then the dissection is carried down to the iliac insertion of the contracted quadratus lumborum and the muscle is cut away from the iliac crest. Finally, the iliolumbar ligament is divided on the convex side of the curve. This step helps to release the tilted fifth lumbar vertebra. This is an extensive operation and it should always be done to the accompaniment of intravenous infusion of plasma supplemented by whole blood if necessary. Because of the danger of shock, the author has found it advisable to postpone application of the corrective turnbuckle plaster until one week after the operation. In two cases, an additional release operation had to be performed on the tight abdominal muscles. This was done by an incision along the iliac crest, division of the fibers of the internal and external obliques at their insertion in the crest, and upward stripping of these muscles, similar to the downward stripping of muscles in the Soutter operation for flexion contraction of the hip.

Despite the extensive operation and the long duration of the treatment, there has been no mortality in this series of thirty-eight cases.

SUMMARY

1. Paralytic trunk deformities may be divided into three groups, depending upon the involvement of abdominal muscles and the quadratus lumborum.

Group I, unilateral paralysis of the abdominals and the quadratus lumborum, results in fixed paralytic pelvic obliquity with scoliosis convex to the paralyzed side.

Group II, unilateral paralysis of the lateral abdominals with intact quadratus lumborum, results in scoliosis convex toward the paralyzed side, but no fixed pelvic obliquity.

Group III, bilateral paralysis of recti abdominis and weakness of lateral abdominal

and transverse muscles result in sagging abdomen, increased lordosis, forward tilting of pelvis, and horizontal sacrum.

2. Following correction by push-and-pull devices and turnbuckle plasters, supplemented if necessary by stripping operations to release contracted structures, permanent correction can be secured, not by fusion of the spine alone, but by the iliocostal fascial graft which effectively supports the tilted pelvis and helps to restore normal muscle balance to the involved trunk muscles. In some cases this should be supplemented by spine fusion.

3. Thirty-eight cases are reported in which forty-six fascial transplants were done with no mortality, and with excellent or good results in thirty cases.

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2. Mayer, Leo: Fixed Paralytic Obliquity of the Pelvis. J. Bone and Joint Surg., XIII, 1, Jan. 1931.
3. Mayer, Leo: Further Studies of Fixed Paralytic Pelvic Obliquity. J. Bone and Joint Surg., XVIII, 87, Jan. 1936.
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DISCUSSION

Dr. Nicholas S. Ransohoff, New York, N. Y.: As many of you know, I have been associated with Dr. Mayer in a good deal of this work. These simply horrible cases that are brought to us are always a challenge to any orthopaedic surgeon's ability. Certainly these cases have been corrected. Some of the patients have been rehabilitated. None of them have been classified as normal people, but they go to school and they can earn their own living.

One phase of this subject Dr. Mayer touched on only briefly,—that is, the earlier control of these pelvic obliquities. There was one case in this series in which we recognized early that the obliquity was developing. It was within four months of his paralysis. We recognized that we could not control the tendency to tilt on the part of the pelvis. Having had previous experience with another patient, we were convinced that probably the proper treatment was early grafting. In a surprisingly short period of time, this patient re-established power in the abdominal muscles. He has gone on for seven, eight, or more years with slight scoliosis, but without the pelvic obliquity, and with the pelvic muscles working as well as the abdominal muscles on that side. So I cannot urge you too strongly, when this pelvic obliquity is developing, to do your fascial transplant early.

Dr. Leo Mayer, New York, N. Y. (closing): I want to thank you for your kind indulgence. Please take this question of pelvic obliquity seriously. Many patients come to our Clinic, who have been treated by excellent men, but the pelvic obliquity has not been recognized. Beautiful operations on the hips and legs have been done, but the paralysis of the body muscles has been entirely neglected. My main purpose in presenting this paper is to urge you to keep your eyes open for this imbalance of the body muscles. I think that by early recognition of trunk muscle imbalance many cases of scoliosis can be prevented. A transplant of fascia is the best way of strengthening the weak or paralyzed muscle.

THE CAUSE OF DISCREPANCY IN LENGTH OF THE LIMBS FOLLOWING TUBERCULOSIS OF THE HIP IN CHILDREN

Arrest of Growth from Premature Central Closure of the Epiphyseal Cartilages about the Knee *†

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Tuberculosis of the hip in children is sometimes followed by marked retardation of growth in the length of the involved limbs. The discrepancy may amount to as much as ten inches. It has long been thought that this inequality is the result of retardation of the rate of growth from disuse. This paper will demonstrate, however, that great bone inequality is the result of premature central closure of the epiphyseal cartilage plates about the knee,—either the lower femoral, or the upper tibial, or both.

Fifteen cases of childhood tuberculosis of the hip have been found in which this complication has occurred. Nine patients were boys, and six were girls. In every case, the age of the patient at onset of the tuberculosis was under seven years. In each case, the leg was immobilized for a long period of time in a cast or brace. In ten cases, both the lower femoral and the upper tibial cartilage plates were involved. In three, there was involvement of the upper tibial cartilage plate alone; and in two, of the lower femoral cartilage plate alone.

The purposes of this article are, first, to describe the roentgenographic appearance of the premature central closure; second, to discuss its probable cause; third, to describe methods of prevention and treatment; and fourth, to present six cases which clearly illustrate the above points.

ROENTGENOGRAPHIC APPEARANCE OF THE LESION

The roentgenographic appearance of this lesion is typical. It is the key to the diagnosis, and suggests the probable pathogenesis. Careful study of the roentgenograms reveals that the arrest of growth follows the formation of a bony lock between the epiphysis and diaphysis at or near the central portions of the cartilage plates. The first indication is the presence of striations across the cartilage plate in its central region (Fig. 1-A). This region becomes the center of intersection of multiple radiating striations (Fig. 4-C), because of continued growth from the uninvolved portions of the plate. This growth likewise produces characteristic changes in the outline of the involved bones. In the femur, the line of epiphyseal union becomes sharply tented, forming an inverted V, and the bicondylar notch is deeper than on the normal side (Fig. 3-A).

In the tibia, the line of epiphyseal union becomes flattened, and in some instances forms an upright V (Fig. 3-A). The tibial spine is underdeveloped, and is often below the level of the peripheral margins of the joint. At times the upper tibial surface becomes almost saucer-shaped (Fig. 3-A). The changes in the form of the line of epiphyseal union of the lower femur and upper tibia may remain for years or may disappear. The changes in the gross outline of the condyles of the femur and tibia remain throughout life, modified only by the early onset of arthritic changes.

* Read at the Annual Meeting of The American Academy of Orthopaedic Surgeons, Chicago, Illinois, January 26, 1944.

† The work at the University of California was supported by the Florence Hellman Ehrman Donation for Crippled Children.

In the cases where the bony lock is eccentrically placed, angulation deformities may result, similar to those following fracture or crushing injury on one side of a cartilage plate [1] (Fig. 6). Characteristic changes are found in the fibula from the continuance of growth in its upper cartilage plate. In some instances the fibular head is raised almost to the level of the knee joint (Figs. 1-B and 4-C). In others, the shaft of the fibula curves behind the tibia as if bowed by a tight string (Fig. 2).

PATHOGENESIS

In all of the cases observed, the premature closure of the epiphyseal line occurred on the side of the diseased hip. In no case was there abscess formation or other evidence of tuberculosis of the knee joint. There was no evidence, therefore, that tuberculosis was the cause of the premature closure.

In searching for its cause, the author was impressed by the constant presence of marked decalcification of the bones of the affected leg. This is due to the long continued inflammatory process in the hip, and to disuse consequent upon the extremely long period of immobilization. Decalcification to this degree must radically change the physical structure of the cartilage plate, and make it more susceptible to trauma.

In normal bone, the cartilage plate is supported firmly by the intact cancellous structure of the adjacent epiphysis and diaphysis. Trauma seldom, if ever, produces an interference with the growth in a normal bone unless a portion of the cartilage plate is crushed or fractured.

In decalcified bone, the cancellous portion loses its normal texture and becomes fluid-like in consistency. This change is often observed in operations upon patients who have had rheumatoid arthritis of the knee for a prolonged period of time. On removal of the joint cartilage, the cancellous substance is soft, and tends to pour forth from the opening. Therefore, the cartilage plate in decalcified bone probably exists as a fragile curtain between the two relatively fluid media. In addition, the decalcified bone is soft and bends easily. This bending may cause changes in the medullary pressure, sufficient to rupture such a membrane. This rupture would occur in the region of the greatest stretch, at or near its center.

In three cases, there was diaphyseal fracture followed by arrest of growth of both centers about the knee. The closure of both centers following the fracture of one bone indicates that trauma, not fracture, is the inciting cause of the arrest of growth. Furthermore, fractures did not occur in all cases.

In these patients, there is always extreme tenderness of the limb on removal of the spica. This tenderness may be due, in part, to bending of the soft bone with resultant stretching of the sensitive periosteum. Therefore, unless it is found to be absolutely necessary, long periods of immobilization in spica casts prior to surgery should be avoided, before the cessation of growth. Arthrodesis should be performed as early as the patient's general condition permits.

Weight-bearing in the spica should be commenced as soon as the operative wound has healed, in order to obtain recalcification of the bone. During the arthrodesis operation, and also at subsequent osteotomies and during each change of casts, the limb should be handled with extreme care. Forceful bending of the limb in an attempt to correct the position of the hip or flexion deformity of the knee should be avoided, especially if the limb shows tenderness. For the same reason, after removal of the spica, the limb should be protected in bed, as many of the patients have sustained fracture merely by turning in bed. Early partial and protected weight-bearing should be encouraged.

TREATMENT

The long bones of the extremity should be measured every six months in children being treated for tuberculosis of the hip. Roentgenographic records should be kept, since

they show, in permanent form, the actual length of each bone. Scanography is the most accurate roentgenographic method for this purpose. If scanography is not available, teleoroentgenograms may be used.

FIG. 1-A

Case 1. M. K. Roentgenogram of the right knee, taken November 11, 1938, four months after refracture of the right femur. There is extreme decalcification of the bones. From their appearance, premature arrest of growth has probably already occurred.

At each examination, the region of the knee should be carefully inspected for the characteristic appearance of premature closure. In suspicious instances and in cases of increasing discrepancy, vitallium markers should be implanted in the shafts of both femora and tibiae. After six months, new scanograms should be taken. The growth from each center can be measured by comparison of the two sets of films. Cessation of growth of one or two centers necessitates determination of the future height of the patient and the future growth of each intact cartilage plate. This is done by the method of prediction of growth described previously.[2] This knowledge permits immediate decision as to the proper procedures necessary to give equalized length to the legs, satisfactory bodily proportions, and adequate final height. Epiphyseal arrest may be used to its full extent. Decision as to the necessity of lengthening operations may be made in the young child.

CASE REPORTS

CASE 1. M. K., male, born May 15, 1927, was admitted to Children's Hospital, San Francisco, June 8, 1936.

At the age of six and one-half years, tuberculosis had developed in the right hip. At nine years, he sustained a supracondylar fracture of the right femur, which healed without overriding. On July 11, 1938, he again fractured the same bone, which healed the second time without overriding (Fig. 1-A). The discrepancy of the leg lengths was one inch at this time. The right hip was arthrodesed July 26, 1938.

On June 5, 1939, shortly after the spica was removed, the patient again refractured the femur by a simple fall. Three inches difference in length was found, of which 0.5 of an inch was due to overriding of the fractured fragments. A femur-lengthening operation was performed, and, by October 3, 1939, healing was complete. The femora were of equal length, and the right leg was only 0.5 of an inch shorter than the left.

However, by June 26, 1940, the difference in length had increased to one inch (Fig. 1-B), and by December 23, 1940, the discrepancy had increased to two inches. Measurements revealed that from December 3, 1939, the right leg had grown only 0.25 of an inch as compared to 1.75 inches for the left. Re-examination of the roentgenograms revealed that the right lower femoral and the upper tibial cartilage plates had prematurely closed. By comparative teleoroentgenographic measurements, and by the use of our method for prediction of growth, it was possible to estimate the time of the premature closure.

On July 11, 1938, at the age of eleven years, the right leg was one inch shorter. As the theoretical growth from the capital epiphysis of the femur from the age of six and one-half years to eleven years was 1.2 inches,

TABLE I

CASE 1. M. K.

Date	Age	Femur			Tibia		
		Right (*Inches*)	Left (*Inches*)	Difference (*Inches*)	Right (*Inches*)	Left (*Inches*)	Difference (*Inches*)
Oct. 3, 1939	12 years 6 months	15	15	0.0	—	—	—
June 26, 1940	13 years 1 month	15	15.7	0.7	11 9	12 25	0 35
Dec. 23, 1940	13 years 7 months	15	16.1	1.1	12 1	12.7	0 6
Growth	12 years 6 months to 13 years 7 months	0	1.1	1 1	0 2	0 45	0 25

this discrepancy was due to destruction of the center of the capital epiphysis by the tuberculous process.

By the time of the second refracture, June 5, 1939, there were 2.5 inches of shortening. The theoretical growth from the entire femur and the upper tibia between July 11, 1938, when the patient was eleven years

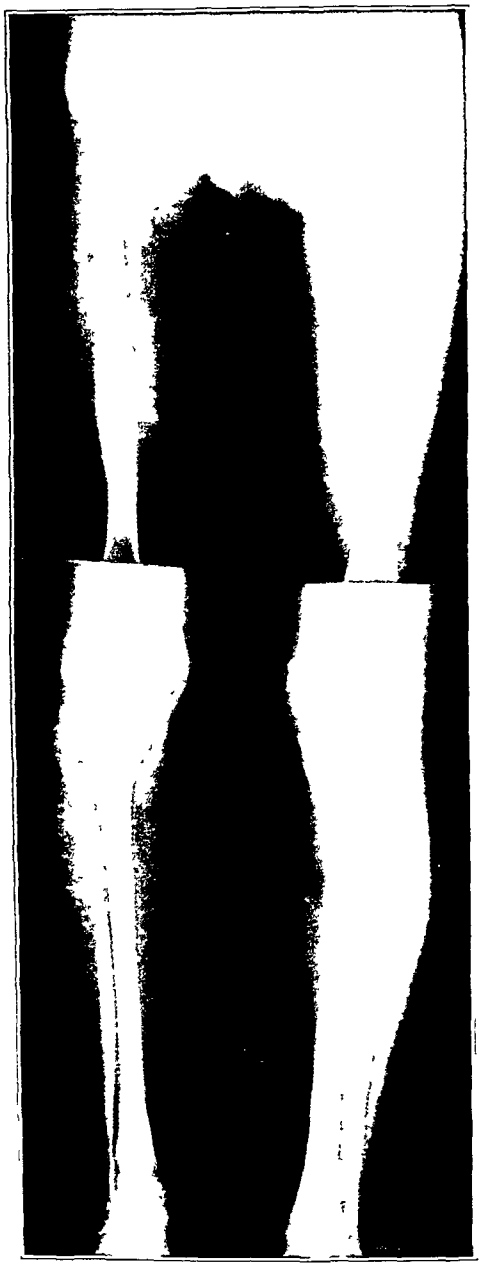

FIG. 1-B

FIG 1-C

Fig. 1-B: Teleoroentgenograms, taken June 26, 1940, show the right femur to be 0.7 of an inch and the right tibia 0.3 of an inch shorter than the left. The intercondylar notch of the right femur has increased in depth. The flattening of the tibial spine and the elevated position of the right fibular head show that premature closure of the epiphyseal cartilage plates of the lower femur and upper tibia has occurred

Fig. 1-C: Teleoroentgenograms, taken June 26, 1942, show that operative arrest of the lower femoral and both tibial and fibular cartilage plates has been done on the normal left leg. This has prevented an increase in the disparity in length. The difference of 1.8 inches is close to the probable final discrepancy.

old, to June 5, 1939, when he was twelve, was 1.3 inches which, plus the previous discrepancy of one inch, was very close to the difference found at that time.

Measurements from teleoroentgenograms are shown in Table I.

These figures reveal that the right femur had not grown since October 3, 1939. Therefore, its cartilage plates were closed at that time. The apparent shortening of the right tibia was increasing. From the age of eleven years to thirteen years and seven months, the theoretical growth from the upper center was 0.65 inches, the discrepancy actually present. Therefore, the premature closure of the lower femoral and upper tibial centers occurred about the time of the first refracture.

On December 23, 1940, when the patient was thirteen years and seven months of age, with a bone age of thirteen years (Todd), and was fifty-six inches tall, the following predictions were made as to the future growth of the normal leg and the probable final inequality in leg length [2]:

Final height	66.3 inches
Growth of normal left femur	3.3 inches
From the proximal center $3.3 \times 0.3 = 1.0$	inches
From the distal center $3.3 \times 0.7 = 2.3$	inches
Growth of short right femur (both cartilage plates closed)	0.0 inches
Growth of normal left tibia	1.7 inches
From the proximal center $1.7 \times .55 = 0.9$	inches
From the distal center $1.7 \times .45 = 0.8$	inches
Growth of short right tibia (upper cartilage closed)	0.8 inches
Total growth of normal left leg $3.3 + 1.7 = 5.0$	inches
Total growth of short right leg (lower cartilage plate)	0.8 inches

From these figures it was evident that if allowed to continue, the final difference in length would increase 4.2 inches to a total of 5.9 inches. Arrest of the left distal femoral cartilage plate and both tibial cartilage plates would decrease the final discrepancy by four inches or to 1.9 inches. The final height would be decreased from 66.3 to 62.3 inches by this procedure.

On March 10, 1941, epiphyseal arrest was performed on the left lower femur and upper tibia. On June 30, 1941, the left lower tibial cartilage plate was fused.

Teleoroentgenograms taken on June 26, 1942 (Fig. 1-C), when the patient was fifteen years and one month old, revealed the following: right femur 15 inches, left, 16.6; right tibia, 12.5 inches, and left, 13 inches.

The total inequality was 2.1 inches. This was more than was calculated, but resulted from the fact that the epiphyseal arrests were performed later than the time of calculation, and the unequal rates of growth continued during the intervening time.

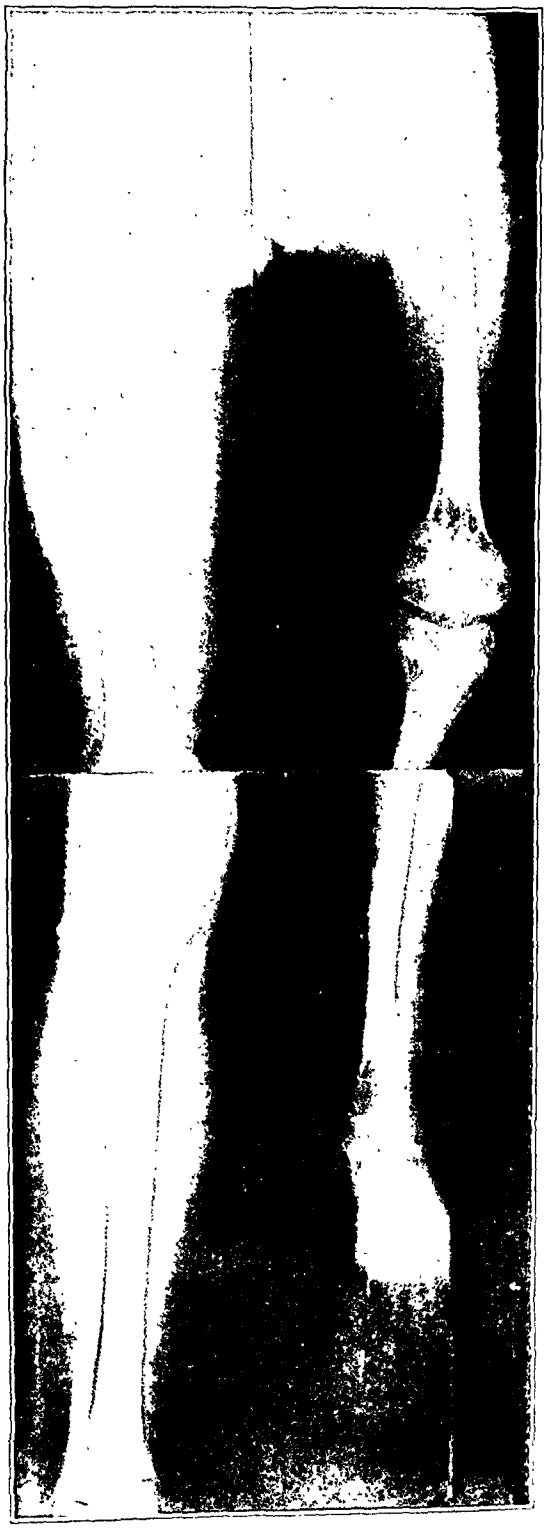

FIG. 2

CASE 2. W. M., *male, aged thirteen years*, was admitted to Children's Hospital, San Francisco, May 11, 1936.

At the age of two years, tuberculosis had developed in the patient's left hip. A spica cast had been worn during

FIG. 2

Case 2. W. M. Teleoroentgenograms of May 11, 1936, show the typical picture of old premature closure of the cartilage plates about the knee. The discrepancy is extreme; the left femur and tibia are 4.8 and 1.6 inches, respectively, shorter than the right. The fibula is curved behind the tibia. *Note the tentlike scarring line of* premature central fusion of the left femur and the saucer-shaped tibial plateau. After this teleoroentgenogram was taken, the normal leg outgrew the left leg by over four inches.

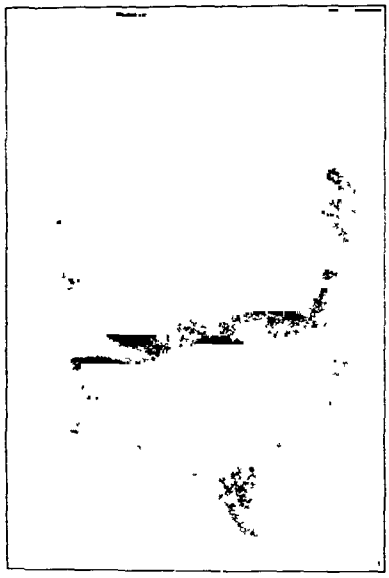

FIG. 3-A

Case 3. J. G. Showing detail of the right knee from scanograms of May 26, 1943. Fully developed growth deformity has occurred from premature central closure of both lower femoral and upper tibial cartilage plates. The articular surface of the tibia is almost saucer-shaped.

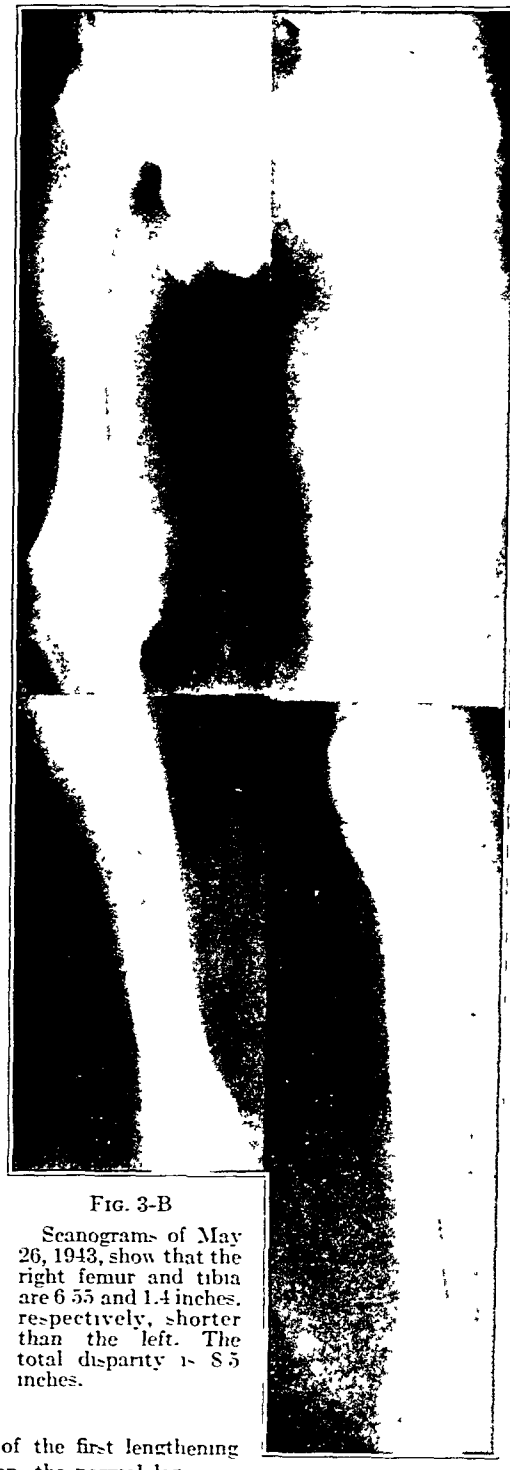

FIG. 3-B

Scanograms of May 26, 1943, show that the right femur and tibia are 6.55 and 1.4 inches, respectively, shorter than the left. The total disparity is 8.5 inches.

most of the intervening years. When he was nine years old, fusion of the left hip had been performed. Following this procedure, the left femur had been fractured during a change of cast. The left femur had been refractured at the age of eleven years.

On May 11, 1936, at the age of thirteen years, comparative measurements revealed a total discrepancy of 6.4 inches (Fig. 2); 4.8 inches of this difference was confined to the femur and 1.6 inches to the tibia. Roentgenograms showed obliteration of the lower femoral and upper tibial epiphyseal lines. The fibula had overgrown the tibia, and was bowed behind the latter bone.

By September 13, 1936, the discrepancy had increased to 6.5 inches. A tibia-lengthening operation was performed on September 24, 1936. A gain of 2.75 inches was achieved by this procedure.

On May 4, 1937, the patient fell, fracturing the femur at the upper margin of the plaster cast. Advantage was taken of this fracture, and a femur-lengthening operation was performed, with a gain of 2.5 inches in length.

The total gain from the two lengthening operations was 5.25 inches. Nevertheless, from the time of the first lengthening operation until after the second lengthening operation, the normal leg grew two inches, so that, in September 1937, a discrepancy of 2.25 inches still remained.

By October 10, 1939, the discrepancy had increased to 4.25 inches. It was then recognized that the continued increase in the discrepancy was due to the premature arrest of the lower femoral and upper tibial growth centers.

For this reason, on October 10, 1939, the lower femoral and upper tibial cartilage plates on the right were fused.

The marked discrepancy first found on May 11, 1936, indicated that the premature arrest had probably existed at or before the age of eleven years. If this fact had been recognized, the proper epiphyseal arrests of the sound leg would have prevented most of the difference from occurring.

CASE 3. J. G., male, born May 13, 1929, was first examined in the author's office on May 19, 1943. At the age of two, tuberculosis had developed in the patient's right hip, and a spica cast had been worn

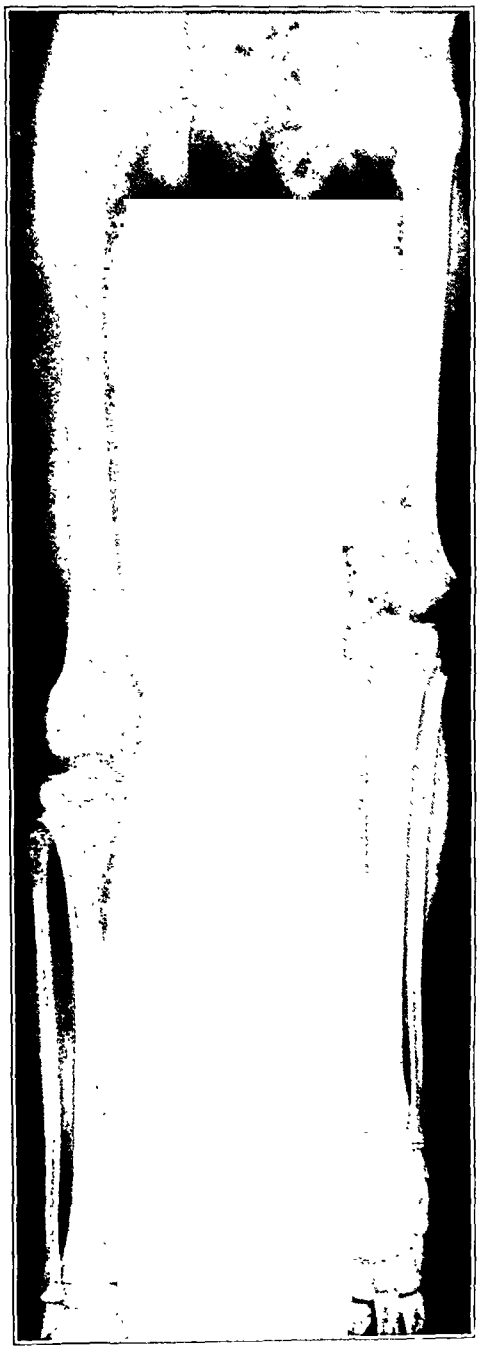

FIG. 4-A

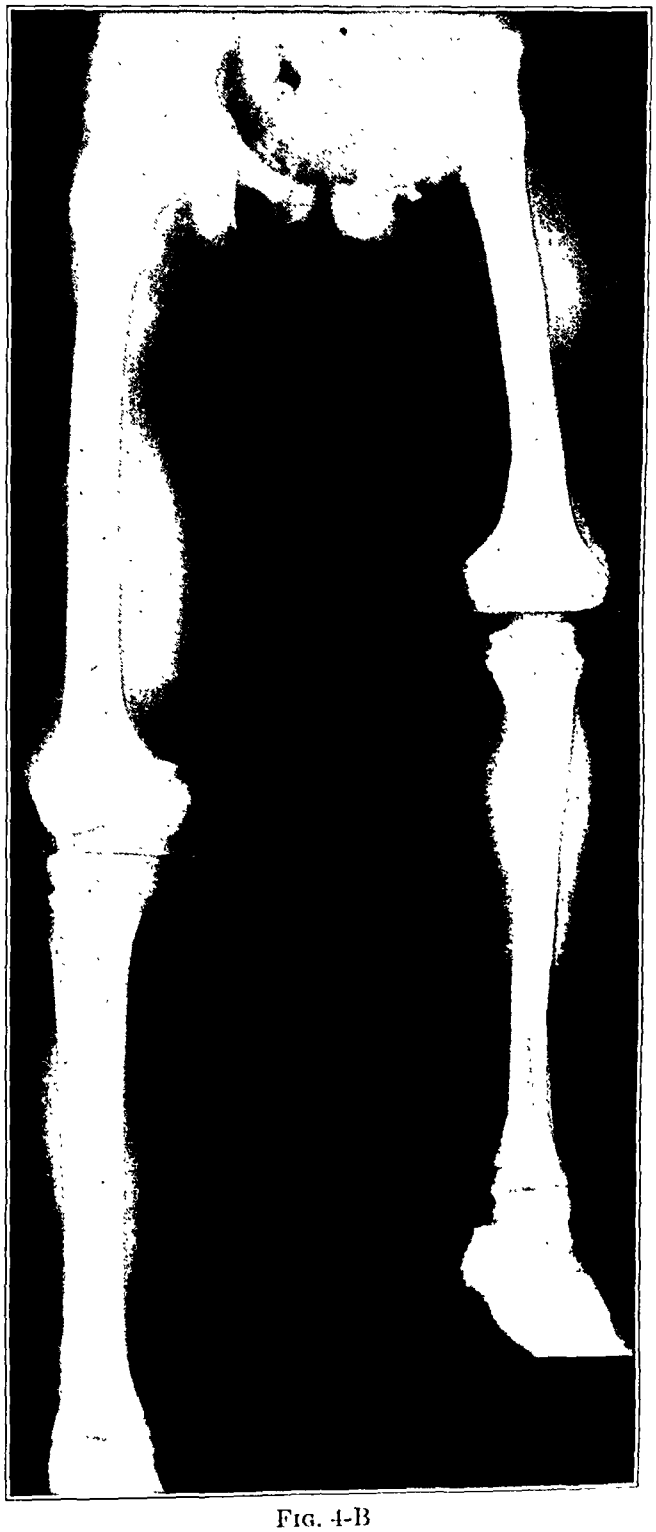

FIG. 4-B

Fig. 4-A: Case 4. R. L. Teleoroentgenograms of December 20, 1939, show that central premature closure of the lower left femoral cartilage plate has been present for some time, as is seen by the typical change in the shape of the femoral condyles. Premature closure of the upper tibial center is not so obvious, but is evidenced by the slight flatness of the tibial contour and the beginning of inversion of the line of the cartilage plate. The fibula is also beginning to curve in toward the tibia.

Fig. 4-B: Scanograms of November 5, 1941, show that despite the performance of epiphyseal arrest of the right lower femur, the disparity has increased through growth of the right upper femoral and the upper tibial centers.

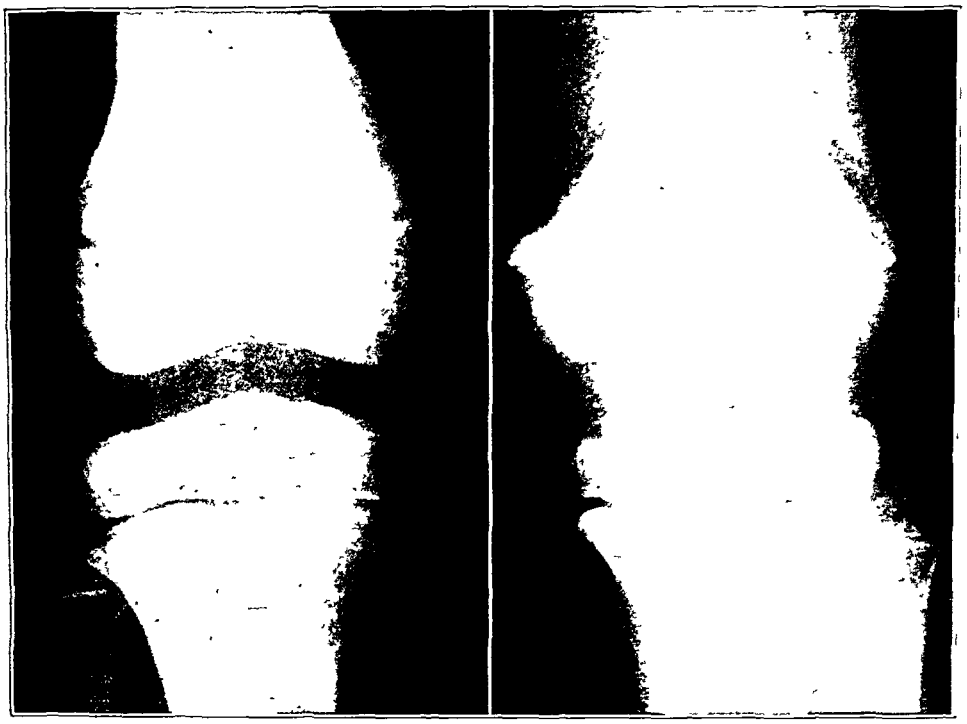

FIG. 4-C

Detail roentgenograms of the knees, taken on November 5, 1941, showing the appearance of premature central closure of the lower femur and upper tibia. Note the flattening of the tibial condylar surface, the slight inversion of the line of the cartilage plate, and the relative positions of the fibular heads.

for several years. No arthrodesis operation was performed upon the hip During the ensuing years, a gradually increasing shortness developed in the patient's right leg.

Examination on May 19, 1943, revealed many healed sinuses about the right hip, which appeared to be ankylosed in a position of 45 degrees of flexion and 5 degrees of internal rotation. There was a varus deformity of the right knee of 15 degrees, and the knee lacked 5 degrees of full extension. Tape measurements revealed the right leg to be 8.5 inches shorter than the left. Scanograms of May 26, 1943, gave the following measurements (Fig. 3-B):

Femur: From the tip of the head to the internal condyle, the left measured 17.75 inches, and the right, 11.2 inches.

Tibia: From the medial joint line to the internal malleolus, the left measured 14.4 inches, and the right, 13.0 inches.

It was estimated that if nothing were done, the discrepancy would increase somewhat over two inches to a final total shortening of about 10.5 inches. Epiphyseal arrest of the lower cartilage plate of the left femur and both cartilage plates of the left tibia were performed to prevent a further increase in difference in leg length.

Operations for lengthening the femur and the tibia are planned for the future, and may be expected to gain approximately five inches of equalization. Later, a shortening of the left leg may possibly be necessary.

CASE 4. R. L., male, born July 6, 1931, was admitted to the New York Orthopaedic Dispensary and Hospital (No. 226324) on August 4, 1939.

At the age of seven years, tuberculosis of the left hip and pulmonary tuberculosis had developed.

Examination on August 4, 1939, revealed the left hip to be fixed in a position of 35 degrees of flexion, and the left leg to be three inches shorter than the right. In December 1939, the hip was arthrodesed (Fig. 4-A). During the convalescence from this operation, an epiphyseal arrest of the right lower femoral cartilage plate was performed. By June 1940, the hip was solidly fused in a position of 40 degrees of flexion, 10 degrees of abduction, and 10 degrees of external rotation.

By November 1941, the discrepancy had increased to four inches, and scanograms revealed the following measurements (Fig. 4-B): right femur, 12.8 inches, left, 9.0, right tibia, 11.0 inches, and left tibia, 10.7 inches. From inspection of the roentgenograms and from the increasing difference in tibial length, it was obvious that there had been premature cessation of growth of the lower femoral and upper tibial growth centers on the left side (Fig. 4-C). It was estimated that, if the lower right femoral cartilage plate had not been

fused at the age of nine years, the final discrepancy in length would have been 11.3 inches. It was also seen that, if nothing further were done at the time of this examination, November 11, 1941, the discrepancy would increase from 4.0 to 7.8 inches.

It was decided to perform an epiphyseal arrest of the upper center of the right tibia. The difference would still increase 1.4 inches through unopposed growth of the upper right femoral center. It was felt that arrest of both tibial centers would decrease the total stature too much. Future lengthenings of the femur and tibia were in order, since over five inches would be necessary to equalize leg length.

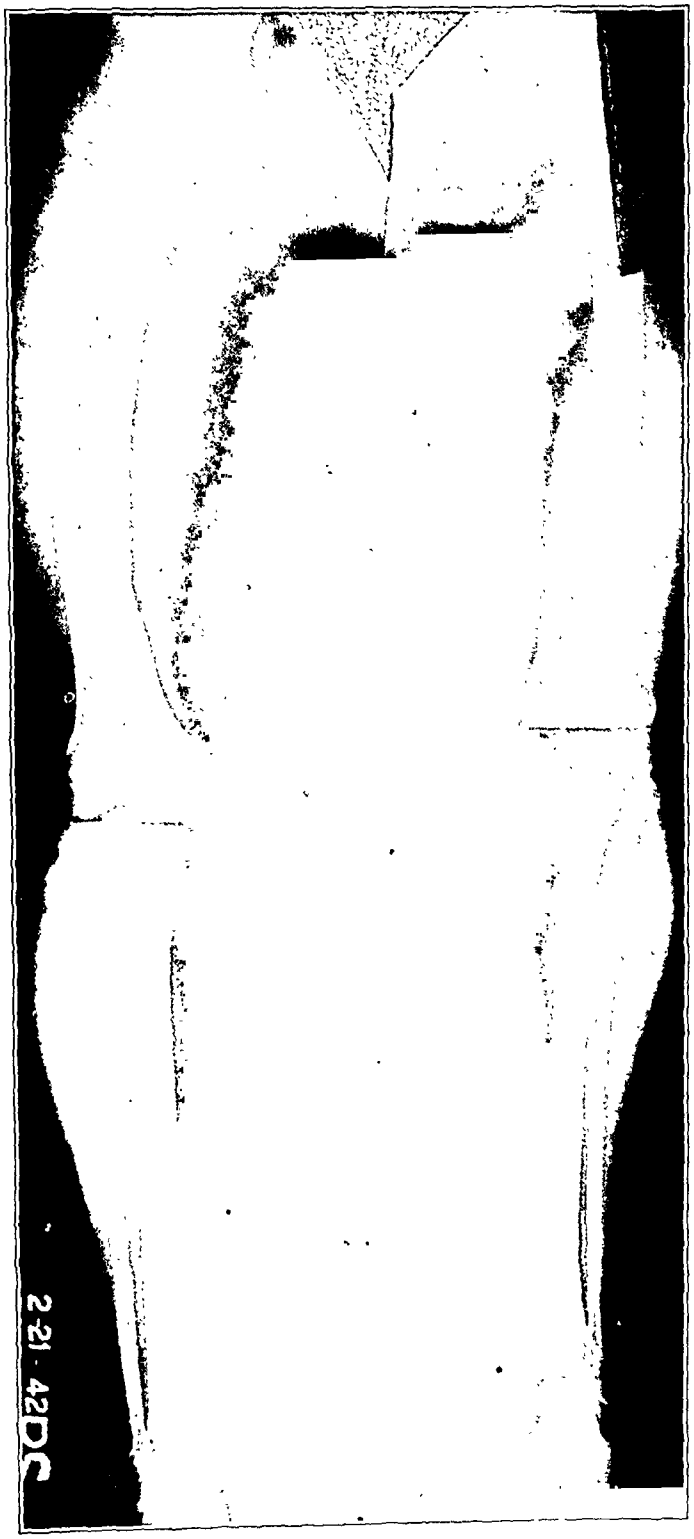

FIG. 5

Case 5. N. H. Scanograms of February 21, 1942, show that the difference of four inches in length has been cut to two inches by shortening the right femur.

CASE 5. N. H., female, born May 24, 1919, was admitted to the New York Orthopaedic Dispensary and Hospital (No. 144675), November 9, 1931.

When three years of age, tuberculosis had developed in the patient's left hip. From the onset of the disease, she had walked with crutches and a brace. On November 9, 1931, at the age of twelve and one-half years, the left leg was three inches shorter than the right. The left hip was arthrodesed on December 7, 1931, and placed in wide abduction to ensure early fusion.

A subtrochanteric osteotomy was performed on August 18, 1932, and the hip was placed in 10 degrees of abduction. By November 1932, the left leg was four inches shorter than the right, and the growth of both legs had ceased. On April 17, 1933, the right femur was operatively shortened two inches.

On February 21, 1942, the left hip was found to be fused in a position of 10 degrees of abduction and 60 degrees of flexion. The gait was excellent, with only a suggestion of a limp. The left leg measured two inches shorter than the right.

Measurements made from scanograms taken February 21, 1942 (Fig. 5), revealed the following: right femur, 14.37 inches, left femur, 13.37 inches; right tibia, 13.45 inches, and left tibia, 13.45 inches.

In this case there was premature closure of the lower femoral cartilage plate alone. The bicondylar width had narrowed and the intercondylar notch had deepened. A moderate generalized arthritic lipping was present.

CASE 6. F. L., female, born January 2, 1929, was admitted to the New York Orthopaedic Dispensary and Hospital (No. 222014), March 30, 1939.

Tuberculosis of the right hip had developed in the patient at the age of three years. She entered because of a marked varus deformity of the right knee (Fig. 6). The right hip was fused solidly in 30 degrees of flexion and 15 degrees of external rotation. There

FIG. 6

Case 6. F. L. Lateral and anteroposterior roentgenograms of the right knee taken March 20, 1939, when the patient was ten years of age. These show premature closure of the upper tibial center. The point of initial fusion is somewhat to the medial posterior portion of the plate as evidenced by the moderate varus and slope of the tibial condylar surface. The medial femoral condyle is overgrown. This is probably compensatory in origin.

was a 10-degree flexion deformity of the right knee and a 15-degree varus deformity of the right upper tibia. The right leg was two inches shorter than the left.

By July 7, 1939, the discrepancy had increased to three inches. On October 4, 1939, the varus deformity was corrected by osteotomy. At the same time an arrest was performed on the left upper tibial and fibular cartilage plates. Two weeks later the left lower femoral center was fused.

On January 15, 1941, the right leg was 2.25 inches shorter than the left. The roentgenograms in this case showed a premature closure of the upper tibial cartilage plate, slightly to the medial side of the center. A valgus deformity of the lower right femur was present, but whether this was compensatory or the result of premature arrest of growth could not be decided from available data.

CONCLUSIONS

Premature central closure of the epiphyseal cartilages about the knee may follow tuberculosis of the hip in children. In the author's opinion, the marked discrepancy in bone length seen in these cases is the result of the arrest of growth from this condition. Extreme decalcification and trauma are the probable causes of this serious complication.

The prevention of inequality in length is dependent upon the early recognition of its cause and the institution of proper methods of treatment to obviate its further increase from growth of the normal leg.

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2. GILL, G. G., AND ABBOTT, L. C.: Practical Method of Predicting the Growth of the Femur and Tibia in the Child. Arch. Surg., XLV, 286, 1942.

PERIPHERAL-NERVE CHANGES ASSOCIATED WITH CONGENITAL DEFORMITIES *

BY BEVERIDGE H. MOORE, M.D., CHICAGO, ILLINOIS †

This paper is part of a study which began a number of years ago with the unexpected discovery of a very obvious neurofibroma in a case presenting an unusual congenital malformation (localized hypertrophy of two fingers). In this particular case, the skin stigmata were not present, or at least they escaped observation. At intervals, several other cases of the same general classification were seen in which the skin stigmata were so obvious that they could not possibly be overlooked. In several of these cases, it was possible to make pathological studies of some of the affected nerves. Once the habit of looking carefully for the characteristic *café au lait* pigmentation was formed, it was observed with increasing frequency in many classes of congenital deformity other than the localized hypertrophy.

A further development has been the observation that one or the other of the parents of a child showing a congenital malformation will frequently show definite stigmata of neurofibromatosis, even though the child himself does not. This observation has been noted especially in cases of club-foot. Probably one reason is that most of these cases are seen very early, and the skin pigmentation may make its appearance later. As a matter of fact, this very thing has happened in one or two cases over a period of years. In one of the early cases of congenital overgrowth with definite clinical evidence of neurofibromatosis, the deformity of the leg and foot was so extreme that amputation seemed the only feasible procedure. The larger nerve trunks were removed entirely for study. They showed the typical nodular formation at irregular intervals along the course of the nerve. However, the nodules occupied only a relatively small proportion of the length of the nerve, and between the nodules the nerve trunk seemed quite normal both to palpation and inspection. For microscopic study, transverse sections were removed from both the nodular and anodular areas at various levels of the nerve. In studying the sections from the nodular areas, it was noted that the pathological changes were not uniformly distributed in the nerve bundles. Some would show the characteristic changes of a definite neurofibroma; other bundles would show a small area of this type of tissue; and still other bundles would show only a relatively small increase in the amount of fibrous tissue, but without the characteristic shredded appearance of the definite neurofibroma. These lesser changes, which may be described as secondary pathological changes, have been given very little attention in the literature. The structure of the nodules has been minutely described. However, in the intervening anodular areas, the secondary type of pathological change just mentioned is much more abundant. The author believes it is a definite and significant part of the picture of neurofibromatosis which has been neglected, since it has been overshadowed by the more dramatic changes in the fibromatous nodules.

In these secondary pathological changes, the basic change is an increase in the fibrous tissue of the endoneurium. Differential stains indicate that the increase is in the collagenous fibrous tissue. Associated with this increase in endoneurial fibrous tissue, are changes in the structure of the nerve tissue proper. Silver stains show that the axis cylinders are often much diminished in numbers. Other stains show changes in the myelin sheath, particularly the absence of Schmidt-Lantermann structures.

The author is stressing these secondary pathological changes (which he has been calling fibrotic degeneration), because they are more widely distributed in the nerve trunk than the definite neurofibroma nodules. Another interesting feature of these secondary

* Read at the Annual Meeting of The American Orthopaedic Association, Cleveland, Ohio, June 7, 1913.
† Deceased

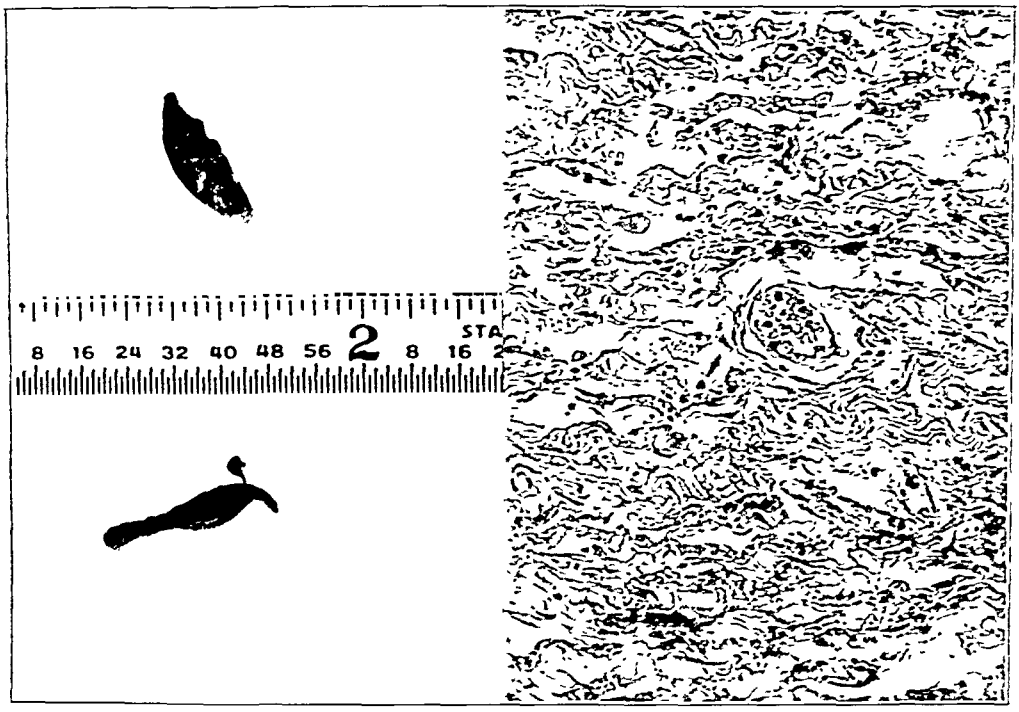

FIG. 1-A FIG. 1-B

Fig. 1-A: E. B. Tumors from two separate bundles of the posterior tibial nerve of a patient with pseudarthrosis of the tibia.

Fig. 1-B: High-power photomicrograph showing, in the middle, the typical wavy appearance of the neurofibroma. This section also shows a certain amount of normal nerve tissue in the darker areas, which is unusual in a neurofibroma. Van Giesen's stain was used.

changes is that, in several definite cases of neurofibromatosis, they were found to be quite marked in the cutaneous nerves. It is believed that they are either an early stage in the formation of a neurofibromatous nodule or an indication of its presence elsewhere in a nerve trunk. As these minor changes began to be noticed, it seemed advisable to check the findings by comparing them with sections from normal peripheral nerves. On inquiry among pathologists, the author was surprised to find that peripheral-nerve tissue is seldom examined routinely, except when it shows obvious gross pathological changes. Accordingly, the author began to make his own collection of presumably normal tissue by routinely examining all available material. Since in a children's orthopaedic hospital there are always spastic patients on whom nerve section is a standard procedure, and supernumerary digits, as well as other deformities requiring partial or complete amputation, in which nerves may be found, the material is fairly abundant. However, it was soon observed that a surprisingly high proportion of this supposedly normal material showed changes corresponding to the secondary pathological changes which have been referred to as fibrotic degeneration. Table I shows the type of deformity or defect in the cases from which peripheral-nerve material was examined.

The striking feature in the table is the high percentage of cases showing nerve pathology, and its relationship to the skin pigmentation considered typical of nerve pathology. It should be emphasized that these statistics must be taken *cum grano salis*. They are accurate so far as the numbers are concerned, but there are many factors that must be taken into consideration in interpreting them. They do not include, by any means, all the cases of congenital deformity which have been seen during the time covered by the study, but only those in which there was a chance to make a study of the peripheral nerves. As to the presence of pathological changes in the nerves, the author has not de-

FIG. 2-A

J. C. Low-power photomicrograph of a section of the cutaneous nerve from a patient with arthrogryposis showing increased fibrosis in both nerve bundles.

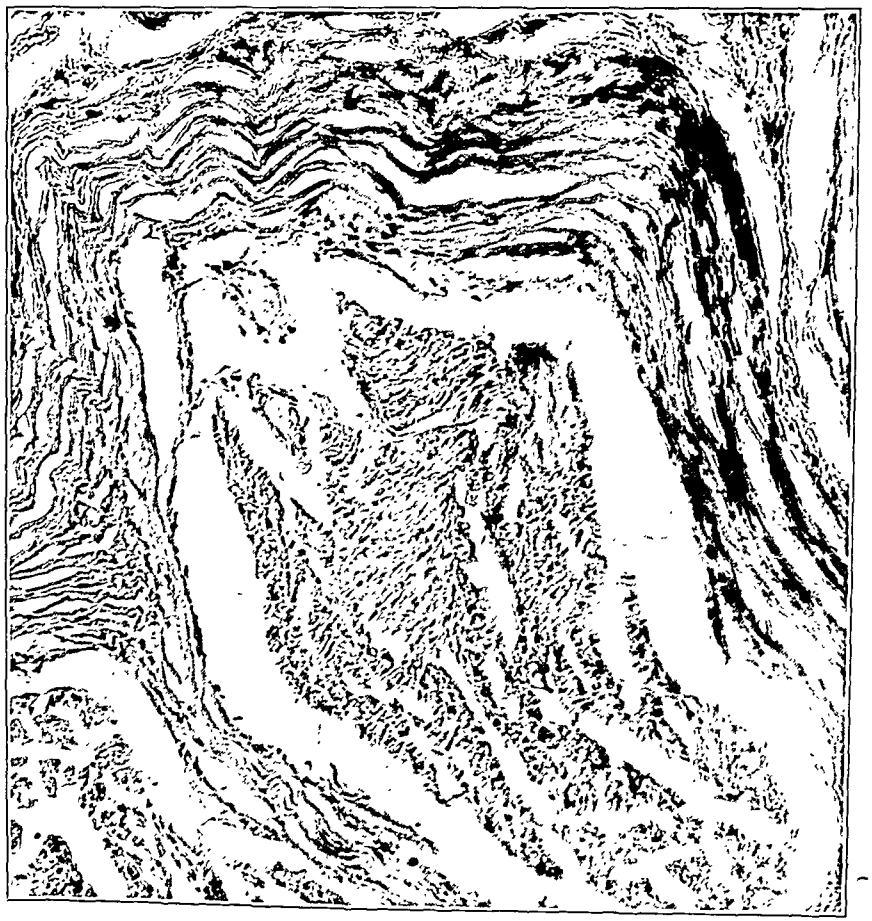

FIG. 2-B

High-power photomicrograph of the upper bundle. There is an area of relatively normal nerve tissue in the middle of the bundle. Above this is an area of marked fibrosis.

TABLE I

Deformity	No of Cases	No with Pathological Changes	Pigmentation
Spastic paralysis	20	13	7
Club-foot	11	11	1
Congenital pseudarthrosis	7	7	6
Congenital absence of bones (tibia *et cetera*)	6	6	0
Congenital hypertrophy of one limb	5	5	5
Macrodactyly	5	5	1
Congenital absence of one limb	3	3	1
Arthrogryposis	5	5	1
Achondroplasia	3	3	0
Multiple exostoses	2	1	0
Supernumerary toes and fingers	2	2	0
Congenital dislocation of the hip	1	1	1
Congenital lipodystrophy	1	1	0
Congenital amyotonia	1	1	0
Sarcoma	3	3	2
Idiopathic scoliosis	3	3	3
Totals	78	70	28

pended on his own meager knowledge (which has increased considerably), but has had the help of a number of pathologists who were willing to study the slides carefully They have not always agreed in naming the pathological changes found, but have agreed on the main features and on the essential point that there was something wrong with the nerve The slides have not all shown a uniform amount of pathological change In those from club-foot, the changes have been slight In congenital absences and hypertrophies they have been very marked Another point that should be noted is the data with regard to

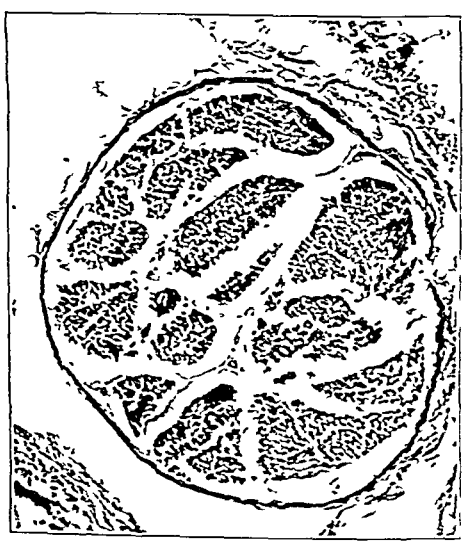

FIG 3-A

FIG 3-B

FIG. 3-A J S A transverse section of the cutaneous nerve from a patient with club-foot appears relatively normal with scattered areas of fibrosis and degeneration

FIG 3-B High-power photomicrograph of one area In the middle of the section there is an area in which the fibrous tissue is beginning to assume the curled and shredded appearance characteristic of neurofibroma

FIG. 4-A

J. M. The low-power photomicrograph of a section from a patient with arthrogryposis shows two nerve bundles with very marked fibrotic degeneration. Two other bundles at the left margin are relatively much more normal.

FIG. 4-B

A high-power photomicrograph of the fibrotic areas shows practically no axis cylinders and very little except fibrous tissue, but it does not have the reticulated structure of a typical neurofibroma. Van Giesen stain was used.

skin pigmentation. In this column have been listed only the cases showing typical *café au lait* spots. Other cases have shown pigmented moles, melanotic areas, and excessive freckling, which may or may not be indicative of peripheral-nerve pathology. These were not included in the "pigmentation" column.

One interesting feature was found in the spastic cases. It had been assumed that the peripheral nerves from them should be normal, yet a high proportion showed distinct fibrotic degeneration. The cases showing pathology were checked for skin pigmentation, and most of them showed some type of skin stigmata, though not always of the typical *café au lait* variety. This finding in spastic cases raises an interesting question. The standard textbook teaching has been that the cause of spastic paralysis in children is injury to the brain during delivery. However, lately there has been a tendency among neurologists to consider that many of the cases are due to an agenesis or imperfect development of certain brain areas. This theory, of course, would place the condition in the class of a congenital deformity rather than a trauma. Possibly the fibrosis found in the peripheral nerves may be an indication of congenital deformity. It is equally possible that the defect or injury in the cerebrum may cause the changes in the peripheral nerve. However, even making all due allowance for these various factors in interpreting the statistics, it does seem apparent that quite a high proportion of congenital deformities do show varying degrees of pathological changes in the peripheral nerves. This observation seems to favor the neurogenic theory of the origin of congenital deformities. This theory was quite popular, especially in the French literature of twenty-five or thirty years ago. It has been ascribed variously to Duplay, Gaugolph, and others. However, there is no evidence that the theory was based on any histological study or was ever checked by pathological investigation. Even though the findings reported in this series seem to be confirmatory of the neurogenic theory, the author is not convinced that the nerve defect is the only cause of congenital deformities.

Bagg's classical experiment shows that certain external factors may have a rôle. In his experiment, pregnant mice were subjected to small doses of roentgen ray. The progeny showed a much higher percentage of congenital deformities than an equal number of controls. Furthermore, the progeny of the treated mice were followed to the fifth generation, and showed a high incidence of deformity. Bagg refers to the deformities as club feet, but to an orthopaedic surgeon they much more resemble congenital amputation or congenital absence of members.

Badgley has recently expressed the belief that arthrogryposis, club-foot, and congenital dislocation of the hip form a class or variety of deformity which is caused by the failure of the limbs to rotate inward in the early embryological stage. This rotation occurs normally during the fifth or sixth week. In other words, some factor coordinating the growth impulse to produce the normal pattern of the limb fails to act at its proper time, resulting in a modified limb. The author believes that this coordinating influence is a function of the nervous system.

SUMMARY

Sections of peripheral nerves from seventy-eight cases of various congenital deformities have been studied with regard to pathology. Of the seventy-eight cases, seventy or 91 per cent., showed definite pathological changes of the nerves to some degree. Excluding the cases of sarcoma and idiopathic scoliosis which might not be considered as congenital, pathological changes were found in 97 per cent. of the slides. These percentages seemed too good to be true. It was felt that perhaps they were "weighted" by the presence of twenty-four cases showing the presence of the typical stigmata of neurofibroma. However, even if these cases are omitted, the percentage still remains at fifty-nine, a figure which would indicate a definite association with congenital deformities.

CONCLUSIONS

Even though there seems to be rather definite association of abnormal peripheral nerve tissue with congenital deformity, the author does not consider it proved that the nerve defect is the cause of the malformation. Nature rarely works as simply as that. Even if the nerve defect were considered as the cause of the malformation, the question would immediately arise as to the cause of the nerve defect and the matter would simply be pushed back one slight stage. More practically, then, it may be concluded that too little attention has been given to the study of peripheral-nerve structure by the average surgeon, and that further study may yield interesting findings. It is also felt that the nervous system may have an unrecognized function in coordinating and guiding the growth processes so that a normal pattern of growth is obtained.

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REDUCTION OF TRANSVERSE FRACTURES OF THE LONG BONES

A Technique Using Flexion and Reverse Flexion

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From the Pavilhão Fernandinho Simonsen of Santa Casa, São Paulo

The principal aim of this report is to emphasize the value of a therapeutic technique, and to bring it to the attention of orthopaedic surgeons. The method deals with the treatment of diaphyseal fractures of the long bones, particularly transverse fractures in which the line of fracture allows a perfect coaptation of the fragments after reduction.

Since the oblique, or spiral, and comminuted fractures are not susceptible to a perfect coaptation of the fragments, they will not be discussed.

Transverse fractures are caused by violent trauma, either direct or indirect. In direct trauma, the bone is fractured at the point of violence; in indirect trauma, the force is transmitted up to the point where the resistance of the bone is overcome. These fractures may be caused by a flexion mechanism or by shearing.

When the surgeon treats a transverse fracture of the shaft of a long bone, where there is much displacement and overriding, the first manoeuvre he usually thinks of is traction and countertraction,—strong or even violent traction when immediate reduction is intended, or continuous direct or indirect traction when the reduction is to require a longer period of time. From the author's experience, this treatment presents a number of faults.

1. *Immediate reduction* by this method varies according to the case, and may require very strong or even violent traction. In spite of violent traction, which may injure the affected limb and other points where traction and countertraction are applied, reduction is not always accomplished. Cases have been reported of rupture of the urethra, caused by the pelvic posts on orthopaedic tables, while serious transverse fractures of the femur were being reduced.

2. *Continuous traction* is indicated principally in fractures of the femur. In fact, since immediate reduction often fails in the treatment of these fractures, this method is recommended by many orthopaedic surgeons. Not only indirect traction, by means of adhesive strips according to the methods of Tillaux, Bardenheuer, and others, but direct or transskeletal traction by means of Schömann tongs, Klapp wire, Steinmann nails, and especially Kirschner wire have been used frequently in this country.

The author believes these methods are not the best for treating transverse fractures of the long bones because:

1. They prolong the duration of treatment.
2. They require apparatus which is expensive, complicated, and inconvenient for the patient.
3. Hospitalization is imperative, especially in cases of fracture of the lower limbs.
4. The methods are not harmless. When the indirect method is used, the skin must be in a very healthy condition and the traction cannot be made with too heavy weights. Direct traction allows the use of heavier weights, thus securing more effective action, but incurs the risk of sepsis—a rare occurrence indeed—and delays recovery of function, which is certainly a drawback. It was noted in the author's private clinic that children with supracondylar fractures, who were treated by immediate reduction, regained the functions of the elbow in a very much shorter time than did those who were treated by direct traction with Kirschner wire.
5. These methods do not always secure a good reduction, and are very often wholly ineffective. Despite the heavy weights used and careful attention to the patient—including several roentgenographic examinations—an open reduction, usually combined with

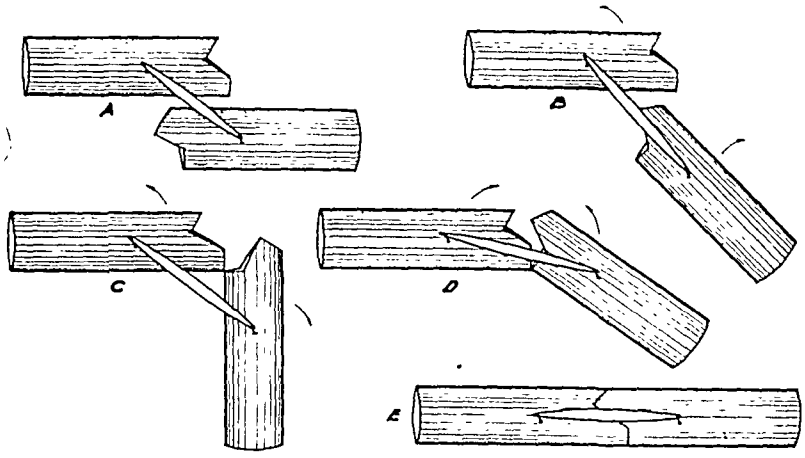

FIG. 1
Reduction by flexion and reversed flexion.

an osteosynthesis, is often imperative.

In view of these inconveniences in the treatment of fractures of this type, the author dealt with the problem of reduction by applying the simple mechanical principle of leverage. This method proved that the power necessary to reduce a transverse fracture is minimal when the fragments are bent until their corners touch each other, and then the direction of the movement exerted is reversed. In this procedure, a perfect coaptation of the fragments is obtained (Fig. 1).

The therapeutic application of this elementary mechanism is the basis of the procedure which the author has been using for the treatment of the diaphyseal fractures of long bones. He calls this procedure, "*technique of reduction by movements of flexion and reversed flexion*".

Let it be supposed, for instance, that two hard sticks are put in contact end-to-end and maintained by means of rubber bands; if they are displaced laterally, they will lose contact, and the contraction of the rubber bands will force them to override (Fig. 2-A). If these two sticks are to be put in contact end-to-end by traction and countertraction, the contractibility of the rubber must be overcome.

By the technique of *flexion and reversed flexion*, only a minimum of power is necessary to put the sticks together. In fact, the flexion is made at the same level at which the

FIG. 2-A
Model showing the overriding of the sticks.

FIG. 2-B
Flexion movement.

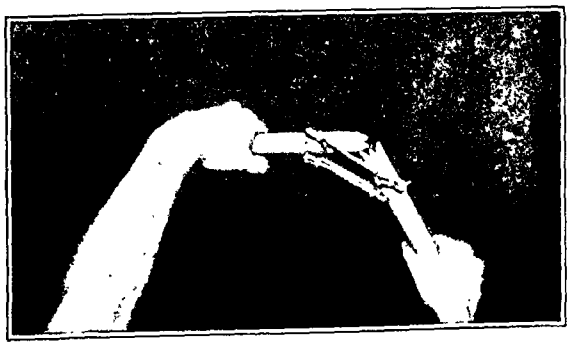

FIG. 2-C
Reversed flexion movement.

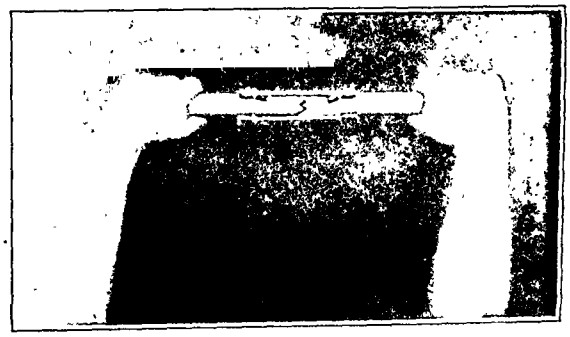

FIG. 2-D
Apposition end to end (reduction).

sticks were separated, so that, until the corners are brought together, the rubber bands will not be stretched (Fig. 2-B). Once the sticks are placed together at an angle, with their ends touching, the operator reverses the direction of the movement (reversed flexion), and the rubber will be stretched just at this moment (Fig. 2-C). The power of reversed flexion varies inversely as the leverage. Suppose the power of contraction of the rubber is eighteen kilograms, the sticks are fifteen centimeters long, and the rubber is inserted five centimeters from the end; this will give then, a set of levers ten centimeters long. The power to stretch the rubber will be divided by three; thus six kilograms of power will be necessary. If the insertion were situated at seven and five-tenths centimeters from the end, the power would be halved, and only nine kilograms would be required. The reduction, by this method, of fractures in which fragments are capable of perfect assembly (jagged fractures) requires less power than reduction by traction and countertraction in which all the muscles surrounding the bones on all four sides are stretched. By using this method, only one group of muscles, that on the concave side, are stretched. These muscles are stretched easily because the leverage multiplies the power. The author has performed 150 reductions by this method, and never has had an accident of injury of the nerve trunk or blood vessels, because, according to Böhler, the muscles, vessels, and nerves slide laterally.

FIG. 3-A

A. J. M. May 14, 1942. Roentgenograms of fracture before reduction.

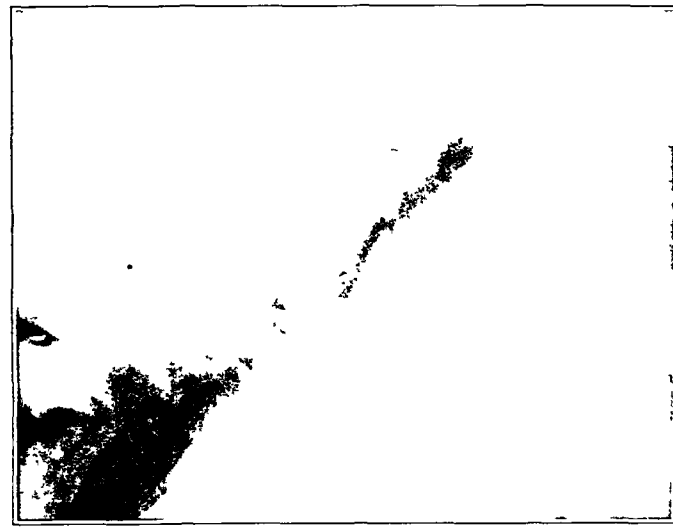

FIG. 3-B

May 16, 1942. Fracture during the flexion manoeuvre, showing the posterior opening. Note the hand of the operator producing the angle at the level of the fracture. (This illustration was made to show the technique. Ordinarily, the roentgenogram is not taken until clinical reduction has been obtained.)

INDICATIONS

This method is indicated when, after careful clinical and roentgenographic examinations, the following conditions are found:

1. A transverse fracture of the shaft of a long bone with marked displacement and

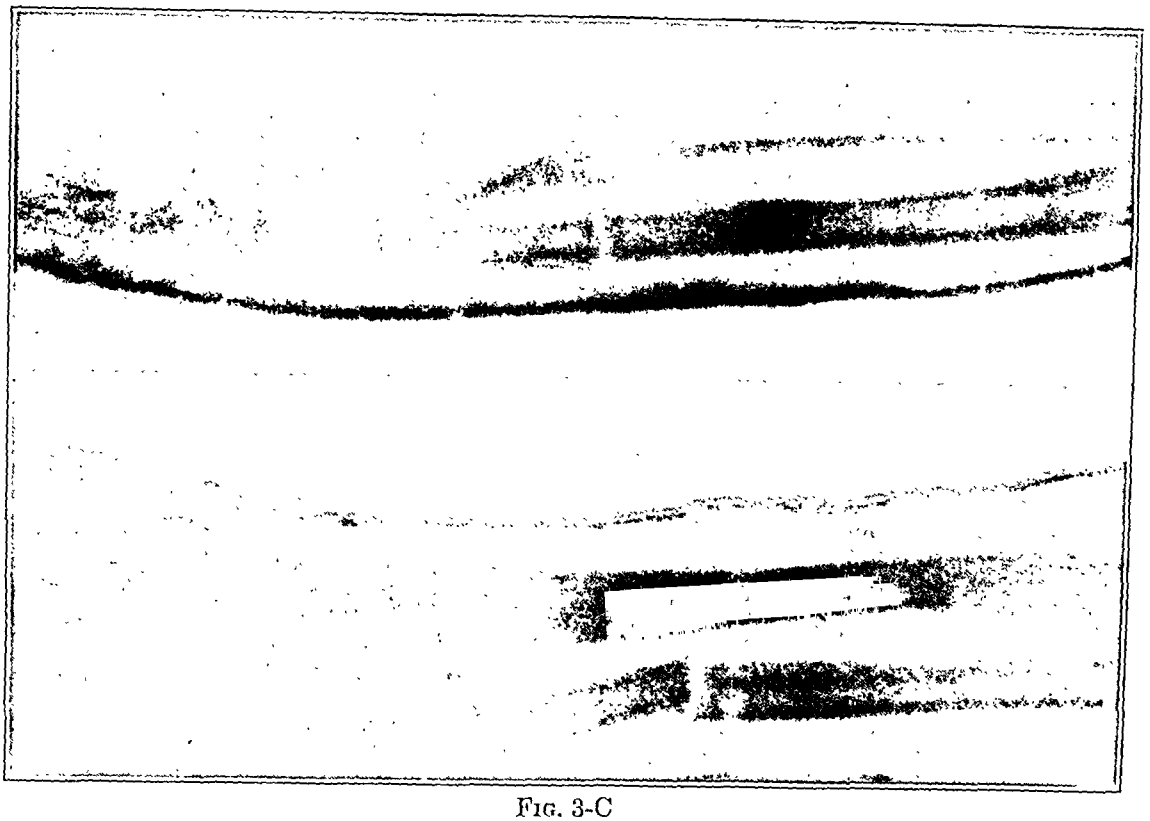

FIG. 3-C
May 16, 1942. Reduction has been secured.

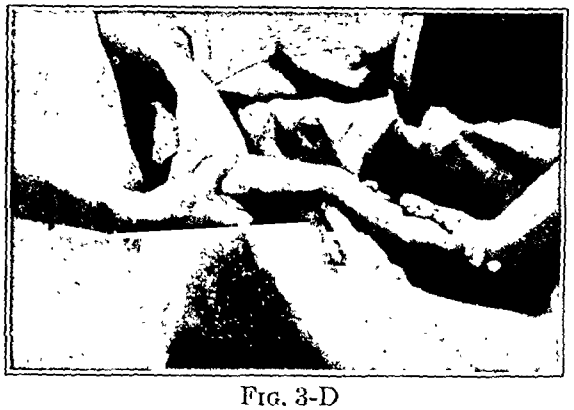

FIG. 3-D
Flexion manoeuvre.

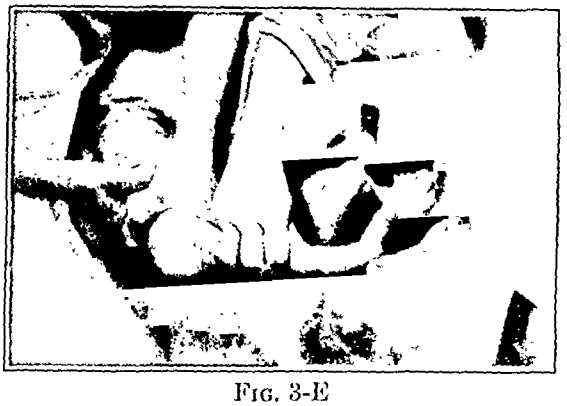

FIG. 3-E
Reversed flexion manoeuvre.

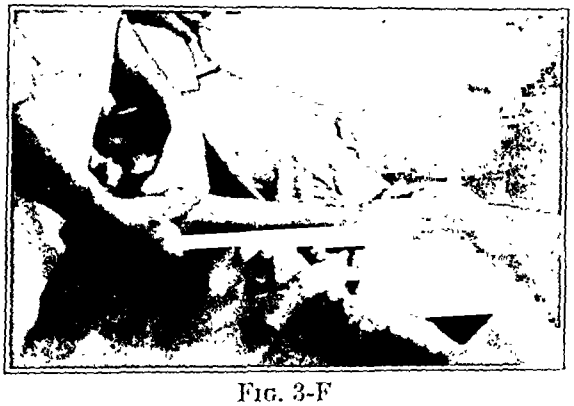

FIG. 3-F
Reduction has been secured.

overriding, in which the fracture line permits anatomical restitution of the fragments.

2. The fragments are long enough to allow leverage manipulation.

3. The fracture is recent,—within four days in children and eight days in adults.

4. The injured limb is not oedematous or only slightly so, because as soon as the fracture is reduced, the fractured limb is fixed in a plaster splint.

Reduction by this method is easier in fractures of the upper part of an extremity, where there is only one bone. In the lower part of the limbs where there are two bones, the manoeuvre is more advisable when both bones are fractured. In the forearm, the reduction is more difficult because muscle strain presents what Masmonteil called "physiological divorce". In juxta-epiphyseal fractures, in which one of the fragments is very

short and is covered by soft parts (muscles), this procedure is not the best. Open reduction is indicated in fractures of the superior fourth of the humerus, the superior fourth of both bones of the forearm, and the superior fourth of the femur.

TECHNIQUE

The method used is the same for the reduction of all fractures of the long bones, when the previously mentioned indications exist. Contraction is abolished by the use of local or block anaesthesia; in a child, ether anaesthesia is preferable. The distal and proximal fragments are aligned in order to suppress axial twisting and angulation. The joints are set in a mid-position to secure relaxation of the muscles, according to the principles of Zuppinger. Overriding is corrected by the *flexion and reversed flexion manoeuvre.* The limb is immobilized carefully in a well-molded plaster cast which includes at least two joints adjacent to the fracture (arm, forearm, thigh, or leg). Check-up roentgenograms should be taken after immobilization in plaster. If any angulation occurs, the plaster should be removed in children within ten days after reduction and in adults within twenty days after reduction, and the deformity should be corrected. This can be accomplished without risk of losing the reduction, because, at that time, fibrous callus will have already formed. Once the deformity has been corrected, the limb is put in another plaster cast until consolidation is complete.

To illustrate the technique, the following case is described:

A. J. M., white, aged eight years, had suffered a transverse fracture of both bones of the right forearm at the junction of the middle and inferior thirds, thirty-four hours previously (Fig. 3-A).

Ether anaesthesia was used, and the patient was placed in the supine position. While an assistant held the elbow, the operator held the hand with the forearm in supination, and the elbow flexed to 90 degrees. The operator gently flexed the forearm with the angle open posteriorly and the point of the angle coinciding with the line of fracture (Figs. 3-B and 3-D). As soon as the corners of the bones were in apposition, the operator made the inverse movement,—*reversed flexion* (Fig. 3-E). With the fingers, the interosseous space

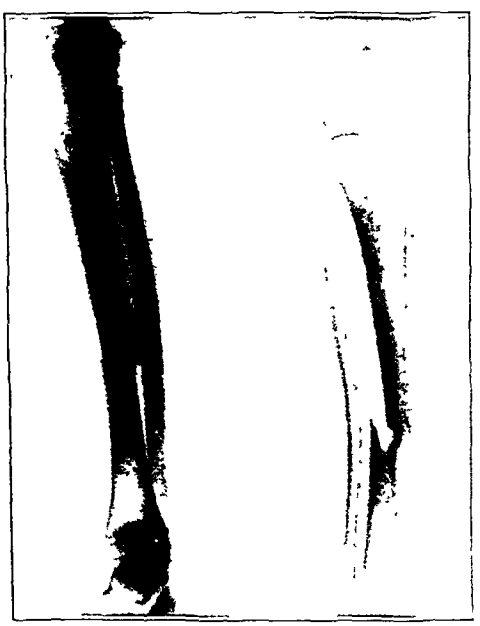

FIG. 4-A FIG. 4-B

Case 2. J. S., white, thirteen years of age, had suffered a transverse jagged fracture of both bones of the right leg in the middle third twenty-four hours previously. The roentgenograms, taken October 25, 1940, show the lateral and anteroposterior views of the fracture before reduction.

FIG. 4-C FIG. 4-D

Reduction by traction and countertraction had been attempted by a colleague, but had not been successful. Direct traction by Kirschner wire had been indicated. The author requested permission to treat the case, and perfect reduction was obtained by the flexion and reversed flexion technique. Roentgenogram taken October 26, 1940.

was reconstituted. A roentgenographic examination was made (Fig. 3-C). (If the reduction had not been secured, the manoeuvre would have been repeated gently and without traction.) When the reduction was accomplished, the forearm was maintained in supination and the elbow at a right angle by means of a plaster cast which extended from the middle third of the arm to the ball of the hand, leaving the fingers free.

ADVANTAGES OF REDUCTION BY FLEXION AND REVERSED FLEXION

1. It is less harmful, because there is no need for traction.
2. It presents less risk, because the muscles, vessels, and nerves slide parallel to the bones while reduction is being performed.

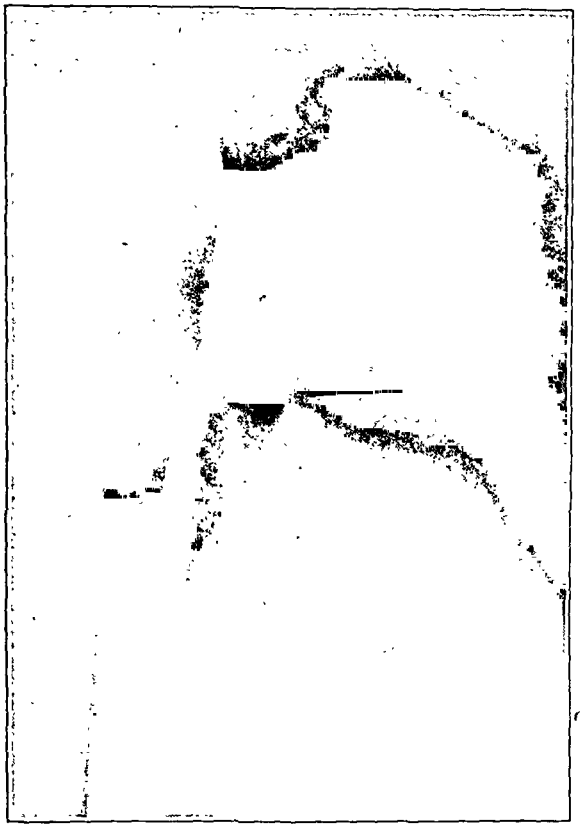

FIG. 5-A

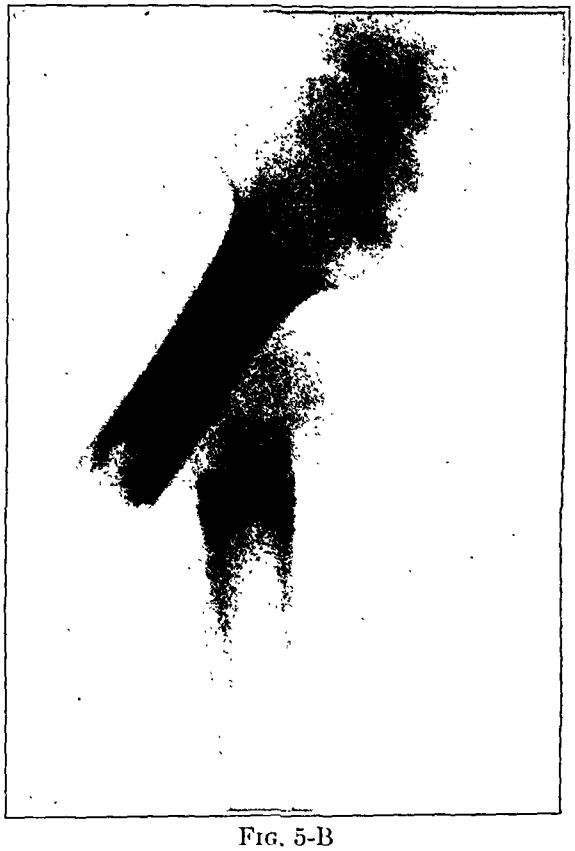

FIG. 5-B

Case 3. A. C., white, twenty-nine years of age, had had a transverse jagged fracture of the middle third of the right humerus eight days previously. Roentgenograms, taken November 13, 1941, show the anteroposterior and lateral views before reduction.

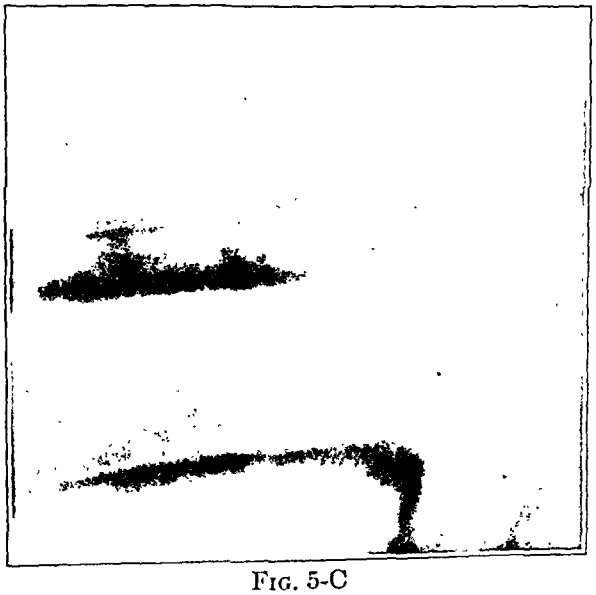

FIG. 5-C
Anteroposterior view after reduction.

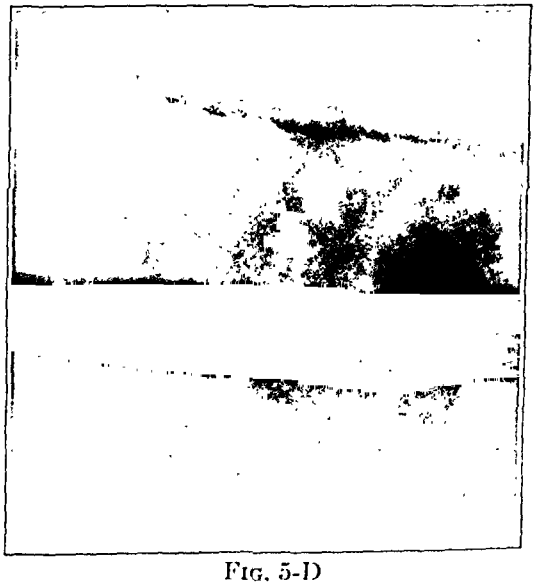

FIG. 5-D
Lateral view after reduction.

3. It is safer, and yields, in the majority of cases, the best anatomical results.
4. It allows an immediate reduction which is its greatest advantage.
5. It is more economical, because it allows immediate reduction and requires only immobilization in a plaster cast.

SUPPLEMENTARY CONSIDERATIONS

In the textbooks on fractures by Böhler, Bauer, Gioia, Key and Conwell, Matti, Tanton, Scudder, Watson-Jones, Wilson and others, descriptions of only traction and countertraction methods are given.

The treatment suggested here has been used by the author since 1938. It is not at all a new conception, but it should be better known. This manoeuvre, with slight variations, has been commonly used for the reduction of Colles's fractures. Campbell in 1924 described a procedure for bloodless reduction of fractures of the femur, that resembled this one. Key and Conwell, and Scudder in their books refer to Campbell's technique. In the

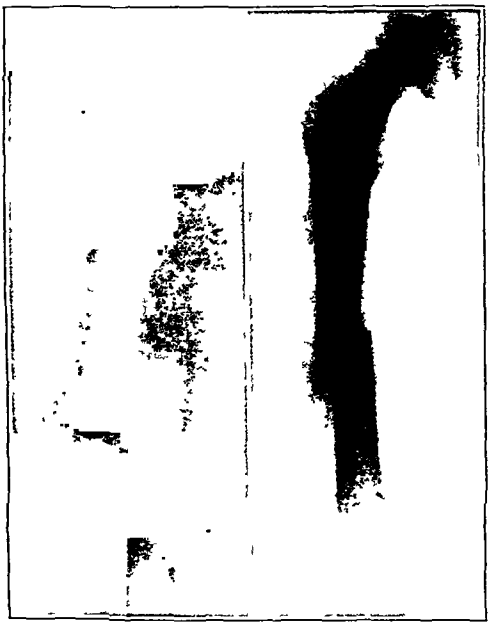

FIG. 6-A FIG 6-B

Case 4. M. S., colored, nine years of age, had suffered a transverse fracture of the middle third of the right femur six hours previously. Roentgenograms, taken September 3, 1942, show lateral and anteroposterior views of the fracture before reduction.

FIG. 6-C FIG. 6-D

Roentgenograms taken October 3, 1942, after reduction.

third Spanish edition, translated from the sixth German edition (1940) of Böhler's book, was printed a drawing after Frisch, which is in some ways similar to the method as here illustrated.

SUMMARY AND CONCLUSIONS

Reduction of transverse, diaphyseal, jagged fractures of long bones by *flexion and reversed-flexion* movements has been described previously, but is worthy of being better known because of its considerable value, its simplicity, and its harmlessness. The method, which is based on an elementary principle of leverage, ought to be applied in every such case of fracture, no matter what limb is affected.

In the complete article, sixteen similar fractures, treated successfully by this method and illustrated by roentgenograms, were included. These have been omitted for lack of space.—*The Editor*

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FUNCTIONAL ARTHROPLASTY

BY JULIUS HASS, M.D., NEW YORK, N. Y.

A survey of the extensive literature on arthroplasty published in recent years reveals the rather striking fact that the articles deal almost exclusively with the materials to be interposed between the osseous elements. The significance of reshaping the bone ends is almost entirely ignored, or is given only the slightest consideration. In the last analysis, the techniques described differ very little from one another. Most orthopaedic surgeons seem to take it for granted that the best approach to the restoration of function is to imitate as closely as possible the original form of the joints.

For a number of years, it has seemed to the author that our reconstructive joint surgery in this respect has gone off on a tangent. Actually, a restitution of the normal joint is possible only in the rarest instances. With all due regard for the great strides in modern joint surgery, we cannot conceal the fact that the result of our surgical endeavor remains an incomplete or—to give it its right name—a false joint: it is scarcely to be compared with the complex structure and subtle mechanics of a normal joint. No matter what method is employed, the degree of success obtained depends upon the extent of the functional adaptation of the parts acquired with use.

Instead of trying to imitate nature, and seeking such a high and seemingly unattainable goal, it has appeared better to the author to divorce himself completely from the traditional concepts, and to reshape the new joint from a *physiological* rather than from an anatomical viewpoint. In the case of the elbow or knee joint, for example, this means altering the joint into the simplest sort of *ginglymus*. Thus, the proximal element is transformed into a transverse wedge and the distal end into a shallow trough. The primary concern has been to *reduce the intra-articular bone contact to the barest minimum, in this manner preventing the bone ends from reuniting, and to permit early motion without friction* (Fig. 1).

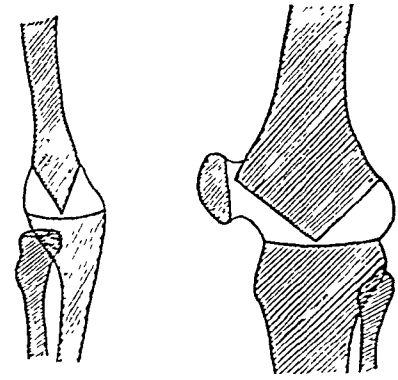

FIG.

Diagrams of arthroplasties of the elbow joint and of the knee joint, showing the lateral views.

In each case, the joint has been altered into the simplest sort of ginglymus. The attachments of the lateral ligaments have been preserved.

The first patient operated upon according to this plan was one with a bony ankylosis of the elbow following a pyogenic infection; the joint was fused into a formless, solid, bony mass. On technical grounds alone, a restoration of the original anatomical joint form was scarcely to be considered. Accordingly, the lower end of the humerus was reshaped into a sharp wedge, while the ulna was transformed into a shallow concavity. The excellent result obtained led the author to employ the same principle in subsequent cases of elbow and knee ankyloses. (The same principle may, by analogy, be applied to the *hip joint*. Here, the acetabulum is deepened to form a *hemispherical concavity*, while the femoral head is reshaped to resemble a *cone*. In this manner, the contact within the joint is reduced to a minimum, and we have had a number of cases in which this procedure has been followed. However, our experiences with the hip joint are too limited to permit the drawing of definite conclusions at present.)

TECHNIQUE

In general, we prefer a wide exposure of the joint by means of a U-shaped skin incision. A curved incision of the joint exposes the synostosis in its entire extent, and permits an

TABLE I

FIFTEEN CASES OF ANKYLOSIS OF THE ELBOW

Case No.	Patient	Sex	Age	Type of Ankylosis	Etiology	Duration of Ankylosis (*Years*)	Date of Operation	Observation Time (*Years*)	End Result
1	M. L.	F	21	Osseous	Pyogenic infection	5	July 1924	12	Excellent
2	H. T.	F	35	Osseous	Gonorrhoea	7	Mar. 1925	11	Excellent
3	E. B.	M	14	Osseous	Osteomyelitis	1	July 1926	3	Poor (recurrent ankylosis)
4	V. O.	M	25	Osseous	Osteomyelitis	14	Oct. 1926	3	Poor (recurrent ankylosis)
5	E. L.	F	29	Osseous	Gonorrhoea	13	Apr. 1927	10	Excellent
6	L. D.	F	18	Osseous	Trauma	2	Jan. 1928	9	Excellent
7	M. S.	F	31	Osseous	Sepsis	1	Dec. 1928	6	Excellent
8	T. A.	F	28	Osseous	Gonorrhoea	1	Aug. 1929	6	Excellent
9	H. R.	F	36	Osseous	Gonorrhoea	2	Nov. 1929	6	Excellent
10	M. K.	F	24	Fibrous	Sepsis	2	Nov. 1930	3	Fair
11	F. S.	M	27	Osseous	Pyogenic infection	3	June 1932	4	Good
12	L. G.	M	21	Osseous	Osteomyelitis	19	Jan. 1934	3	Poor (recurrent ankylosis)
13	M. H.	F	32	Osseous	Sepsis	2	May 1935	2	Good
14	T. M.	F	21	Osseous	Tuberculosis	17	Jan. 1936	2	Excellent
15	H. G.	M	15	Osseous	Lues, congenital	14	Feb. 1936	2	Good

This series of fifteen cases of ankylosis of the elbow shows:

End results: Excellent ..... 8 (53 per cent.)
Good ..... 3 (20 per cent.)
Fair ..... 1 (7 per cent.)
Poor ..... 3 (20 per cent.)

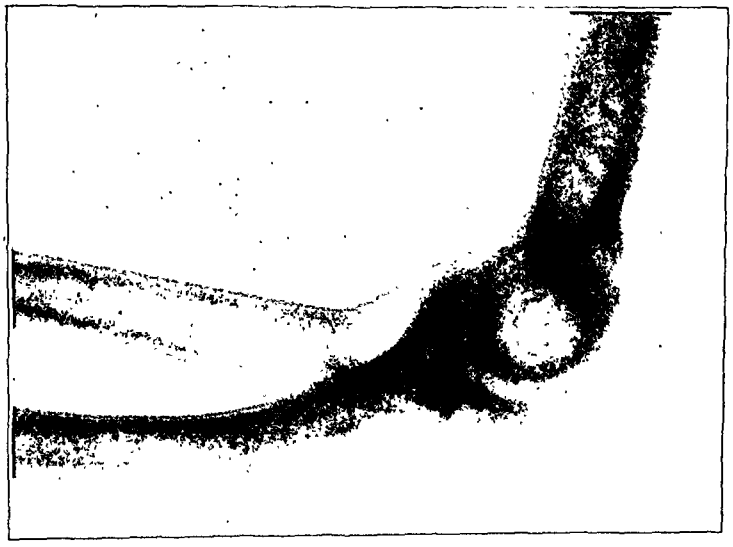

FIG. 2-A

Fig. 2-A: Case 1. M. L. Roentgenogram of the elbow joint, taken before arthroplasty, shows osseous ankylosis in flexion following pyogenic infection (Table I).

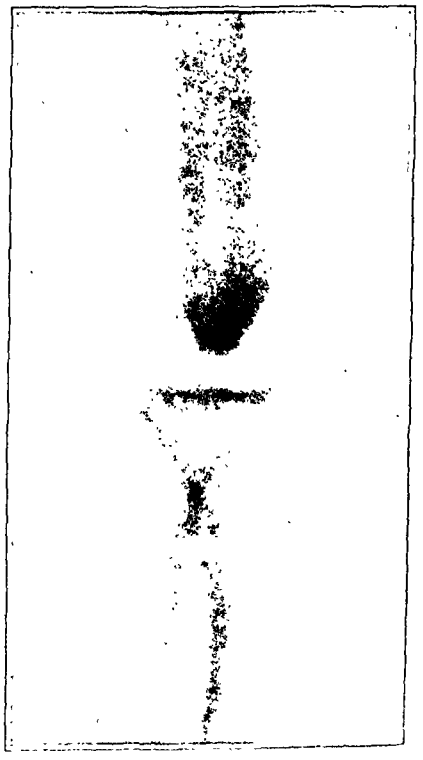

FIG. 2-B

Fig. 2-B: Roentgenogram, taken three weeks after arthroplasty, shows formation of a wedge-shaped end of the humerus and a shallow trough in the ulna.

excellent view into the interior of the joint. After the fusion has been broken up with chisel and mallet, the joint ends are reshaped in the manner previously described, while the lateral ligaments are most carefully guarded. The bone ends are then smoothed off with a rasp and tapped briskly with a small mallet. In this way, the trabeculae are turned down, and bone hemorrhage is controlled. An advantage of this method is the preservation of lateral ligament attachments, and the relatively insignificant sacrifice of length; the latter feature is especially important in the case of the knee joint.

Although function could be restored without interposition, nevertheless we have employed a free layer of fat, obtained from the lateral aspect of the thigh and used to cover the convex end of the joint. The only real purpose it serves is to fill in the dead spaces in the anterior and posterior joint compartments, and, at the same time, to prevent the collection of blood from excessive oozing.

After closure, the joint is immobilized in extension by means of plaster, and skin traction is provided and continued for three weeks. Thus, contact between the bone ends is avoided and, at the same time, regenerative processes are not interfered with. Upon removal of the bandage, active exercises are begun. Passive exercise or forced movements are specifically forbidden, since they frequently occasion severe reaction, and so thwart the purposes of the procedure. As a rule, in cases treated by this method, there is possible from the outset a painless and frictionless range of voluntary motion, which gradually increases as the muscles gain in power. Should sensitiveness and swelling of

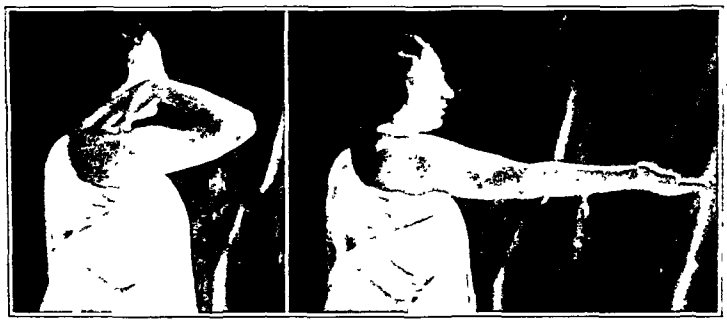

FIG. 2-C FIG. 2-D

Photographs, taken three months after arthroplasty, show range of motion in the elbow joint.

FIG. 2-E

FIG. 2-F

Roentgenograms, taken six years after arthroplasty, show elbow joint in extension and in flexion.

There is excellent joint space with smooth articular surfaces. The proliferation at the end of the humerus is due to outgrowth of the internal epicondyle.

FIG. 3-A

FIG. 3-B

Fig. 3-A: Case 6, L. D. Before arthroplasty, showing osseous ankylosis after a compound fracture.
Fig. 3-B: One month after arthroplasty. The light mass represents the interposed fat.

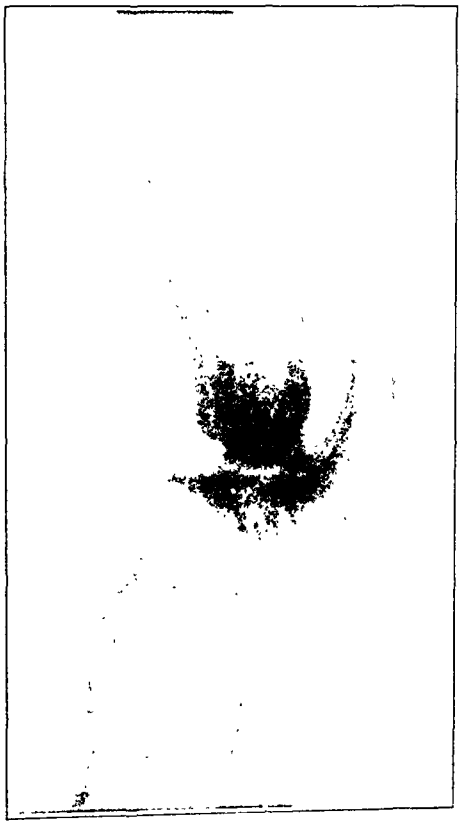

FIG. 3-C

FIG. 3-D

Roentgenograms, taken two years after arthroplasty, show the elbow joint in extension and in flexion.

As a result of functional adaptation, the articular ends are rounded off and smoothed, the trough of the ulna is deepened, and on the dorsal end of the ulna a new olecranon-like process has developed.

the joint occur, the joint is put at rest until the active symptoms have subsided. By periodic roentgenographic control, the course of bone regeneration and the development of a new bone structure and contour can be followed.

Elbow Joint

Operative Procedure. A curved incision, convex downward, is made around the olecranon, which is chiselled off obliquely along with the attachments of the triceps tendon. The ulnar nerve is meticulously dissected out of its sulcus and retracted medially. The synostosis is then broken through by means of chisel and mallet, the lateral ligaments being preserved as carefully as possible. The distal end of the humerus is formed into a sharp wedge, while the ulna is reshaped to resemble a shallow trough or concavity perpendicular to it. If there is also a radio-ulnar fusion, it is broken up, and the head of the radius is either formed into a wedge directed toward the ulna or is resected entirely. The scarred capsular tissues are then removed, the bleeding is controlled, and the bone ends are smoothed off by means of a rasp and mallet. The end of the humerus is covered with a flap of fatty tissue, taken from the thigh and fastened to the humerus with catgut. At this stage, the bony tip of the olecranon is removed from the triceps tendon, and the latter is fixed to the periosteum of the ulna with silk. The removal of the olecranon is recommended, since it predisposes to limitation of extension. Hyperextension need not be feared as the biceps muscle is strong enough to counteract it. After closure of the wound, skin traction is applied (about two pounds) and the arm is fixed in plaster in extension for three weeks, with the forearm in slight supination.

After the cast has been removed, and traction has been released, the after-care includes active exercises with a pulley. Again, passive exercise and massage are to be scrupulously avoided. If difficulties arise in the matter of mobility, or if swelling and pain appear, the elbow should be placed at rest in a plaster cast until all evidence of swelling and irritation have disappeared.

Knee Joint

Naturally, the situation in the knee is one of much greater complexity than in the elbow. In the elbow, the primary desideratum in function is mobility, and some laxity of the joint can be quite compatible with useful function, particularly since this is appropriately governed by the action of the muscles. In the knee, on the other hand, the success of the arthroplasty depends not only upon the possibility of achieving motion, but also upon doing so with maintenance of maximum stability and weight-bearing capacity. The knee joint presents a particularly exacting problem, especially in the matter of lateral stability. However, as previously noted, this method makes it possible to preserve intact the attachments of the lateral ligaments, provided, of course, they are still present. Thus the knee is guarded against excessive lateral mobility, and replacement of lateral ligaments by operation is avoided. Of still further significance is the fact that so little length is sacrificed that the ultimate shortening is negligible.

FIG. 3-E FIG. 3-F

Photographs, taken two years after arthroplasty, show range of motion in the elbow joint.

Operative Procedure. A curved infrapatellar incision is made. After a tangential removal of the tuberosity, the patella is detached, by chisel, from the femur, along with the soft parts, the entire flap being reflected proximally. The synostosis is broken up with

osteotome and mallet, care being taken to preserve the attachment of the lateral ligaments. The restoration of the joint surfaces follows the principles already described. The condyles are first removed from the femur and a wedge is formed, with a long anterior and a shorter posterior surface. Only enough bone is removed from the tibia to create a shallow trough perpendicular to the femur. The under surface of the patella is resurfaced and flattened, and all the surfaces are smoothed with a rasp and mallet. After extirpation of the altered capsular tissues under careful hemostasis, a layer of fatty tissue, large enough to completely cover the lower end of the femur including the inferior surface of the patella, is removed from the thigh and is interposed between the fragments. The tuberosity is reattached to its original site by means of a metallic nail or screw, and the soft parts are sutured. After closure of the skin wound, adhesive traction is applied to the leg (about four pounds) and the knee is immobilized in extension by means of plaster. Three weeks later, traction and plaster bandage are removed, and active flexion exercises are begun. Should pain or swelling supervene, the joint is again placed at rest in a plaster cast. Weight-bearing with the aid of crutches is permitted after two months.

DISCUSSION

Fourteen elbow and nine knee arthroplasties, with a follow-up period of more than five years in some cases, warrant an appraisal of the procedure described.

All the cases in this series healed *per primam*. The author believes that this circumstance is not just fortuitous, but rather the result of simplification of the type of joint surfaces, and avoidance of scar-tissue formation which is traceable to dead spaces in the joint.

In evaluating the end results, emphasis has been placed on function. The rating *excellent* has been applied to those cases with a practically normal restoration of joint function; *good* to those with complete extension and at least 90 degrees of flexion; *fair* to those with less flexion; and *poor* to those with recurrent ankylosis, persistent pain, or a flail joint requiring a brace for control or relief. In no case has there been more than one-half inch of permanent shortening.

FIG. 4-A

Case 1 (Table II). G.K. Roentgenogram of the knee, taken before arthroplasty, shows osseous ankylosis following gonorrhoeal infection.

In so far as fibrous and bony ankylosis are concerned, there is technically no difference, and one should studiously avoid leaving behind any island of joint cartilage. In the one case in which this was done (Table II, Case 7), the result was quite unsatisfactory.

The best results were achieved in cases of traumatic ankylosis; the next in those of gonorrhoeal origin; while the poorest results followed osteomyelitis. In one case of ankylosis of the elbow following osteomyelitis (Table I, Case 3), bony union supervened soon after the operative procedure in spite of primary healing of the wound. Later roentgenographic study showed periosteal proliferation and myositic changes, accounting for the failure on the basis of a reactive inflammation. Of particular note, because of the excellent result obtained, was a case of elbow ankylosis which followed tuberculosis (Table I, Case 14). Nevertheless, joint tuberculosis remains a *noli me tangere* and, just as osteomyelitic or pyogenic ankyloses, should be

FIG. 4-B FIG. 4-C FIG 4-D

Showing range of motion thirteen months after arthroplasty The scar on the thigh is due to the removal of fat.

FIG. 4-E FIG. 4-F

Kneejoint in extension and in flexion, thirteen months after arthroplasty. Note the increased density of the articular surfaces produced by function.

FIG. 5-A

Case 4, P. T. Knee joint, before arthroplasty, shows osseous ankylosis following gonorrhoeal infection (Table II).

FIG. 5-B

Three weeks after arthroplasty, showing wedge-shaped end of the femur and shallow trough of the tibia.

FIG. 5-C FIG. 5-D FIG. 5-E

Photographs, taken one and one-half years after arthroplasty, show range of motion in the knee joint.

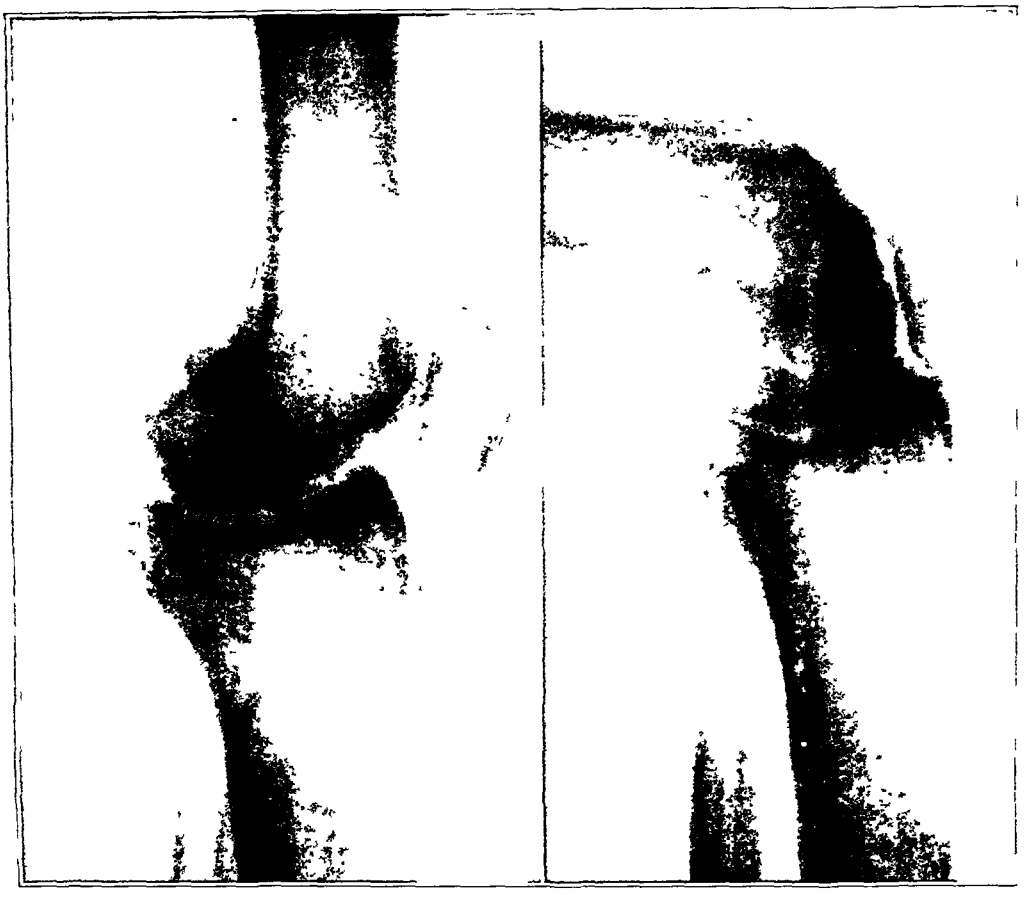

FIG. 5-F FIG. 5-G

Roentgenograms, taken two years after arthroplasty, show knee joint in extension and in flexion. The development of functional adaptation is pronounced. Note the reconstruction of condyles and the condensation of bone trabeculae.

attacked only on exceptional grounds. When an arthroplasty has been decided upon, in cases of this type, it has been where the original infection was a remote one, without the slightest trace or indication of intervening inflammation or reactivation, such as pain, swelling, or fever.

In previous papers [1, 2] the follow-up period was too short to justify competent conclusions as to the ultimate form of the joint ends and their structural transformation. At the present time, however, more definite observations indicate that the bone ends follow the *laws of bone transformation, adapting themselves completely to the new functional demands, and eventually attaining an outer form and inner structure corresponding to these demands.* At the outset the new joint is a pure ginglymus; later, under the influence of function, the ends are rounded off and smoothed, and the trough constituting the distal portion of the joint is deepened. In the elbow, an olecranon-like bony projection may develop (Figs. 3-C and 3-D), while in the knee a condylar form of reconstruction frequently occurs (Figs. 5-F and 5-G). Finally, from the rudimentary ginglymus a new gliding joint mechanism develops.

This development follows physiological lines. The author believes that the operation merely creates a rational basis for this development, which consists of stabilizing and rendering functionally competent the labile mechanism. As far as could be observed in this series of cases, this development can only be expected after one to two years, although the comparatively painless mobility obtained immediately after the operation is in itself an achievement.

TABLE II

NINE CASES OF ANKYLOSIS OF THE KNEE

Case No.	Patient	Sex	Age	Type of Ankylosis	Etiology	Duration of Ankylosis (*Years*)	Date of Operation	Observation Time (*Years*)	End Result
1	G. K.	F	31	Osseous	Gonorrhoea	6	June 1925	12	Excellent
2	M. G.	F	17	Osseous	Sepsis	2	June 1925	12	Excellent
3	M. B.	F	30	Osseous	Gonorrhoea	2	May 1926	11	Excellent
4	P. T.	F	28	Osseous	Gonorrhoea	9	June 1928	10	Excellent
5	A. L.	M	22	Osseous	Sepsis	9	Oct. 1929	3	Good
6	R. S.	F	31	Osseous	Gonorrhoea	2	Sept. 1930	7	Good
7	L. G.	F	26	Osseous	Gonorrhoea	2	Jan. 1931	3	Poor (recurrent ankylosis)
8	K. N.	F	32	Osseous	Gonorrhoea	14	Feb. 1932	5	Good
9	H. H.	M	24	Osseous	Rheumatoid arthritis	6	Apr. 1934	3	Poor, flail joint, and persistent pain.

This series of nine cases of ankylosis of the knee shows:

End results: Excellent..... 4 (44.4 per cent.)
Good..... 3 (33.3 per cent.)
Fair..... 0 (0 per cent.)
Poor..... 2 (22.2 per cent.)

One might object to the author's method on the grounds that it is nothing more than a form of partial joint resection. It should be emphasized that, in contrast to this procedure, resection leads to a permanent bony defect, and a flail and unbalanced joint; that it is accompanied by a permanent loss of muscle power; and that a functional adaptation of bony structure, such as is seen with this method, never develops.

SUMMARY

Fifteen cases of elbow-joint ankylosis and nine cases of knee-joint ankylosis have been treated by the author's method. The principle employed is that of restoring function by the establishment of a simple ginglymus, in order to reduce the bone contact to a minimum. Further development follows the functional adaptation of the parts.

A satisfactory follow-up period, of more than five years in some cases, permits an evaluation of the end results. The arthroplasty itself is achieved more rapidly, is more reliable, and offers a greater amount of controlled voluntary motion than is obtained by other methods. Perhaps under conditions associated with war surgery, this technique may be accepted as a simple and effective method in the difficult field of arthroplasty.

NOTE: Most of the illustrations of this article have been previously published, and appeared in one or the other of the articles by the author listed in the References.

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1. HASS, JULIUS: Neue Gesichtspunkte zur Arthroplastik. Zentrabl. f. Chir., XLVIII, 2702, 1925.
2. HASS, JULIUS: Die Mobilisierung ankylotischer Ellbogen- und Kniegelenke mittels Arthroplastik. Arch. f. Klin. Chir., CLX, 693, 1930.

THE DETAILED OPERATIVE TECHNIQUE FOR OPEN REDUCTION AND INTERNAL FIXATION OF FRACTURES OF THE LONG BONES *

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The success of operative reduction and internal fixation is in large part dependent upon the technique employed in the operative procedure. To give the maximal chance of success, this technique must accomplish a close approach to absolute rigidity of fixation of the fracture fragments, wide distribution of the strain borne by the fixation elements, a minimal amount of trauma to the soft-part circulation surrounding the fracture site, and a minimal risk of infection.

The technique here described is the result of the study of some 1022 open reductions and fixations over a period of twelve years, which have been done by various members of our Hospital staff, followed by the whole group, and subjected to open discussion by the whole group over a follow-up period of from one to five or more years. It represents the consensus of that group as to the proper principles of technique to be followed in open reductions and fixations. Evidence from animal experimentation has been used to augment clinical experience whenever a moot point has arisen which has been capable of proof by experimental procedures.

Timing of Operation

It might be stated here that the time at which open reduction is performed in a fresh fracture is a matter of considerable importance.

It is indeed a great advantage to perform the operation within the first few hours after injury. It is best done before the tissues, particularly the muscles, have become infiltrated by blood and exudate to the point of induration and loss of tissue elasticity. This early period, therefore, varies somewhat chronologically. Usually it means within the first eight to twelve hours after injury. Done within that period of time, the operation is performed more easily and with less trauma to bone and soft parts; there is less bleeding; and there is less risk of infection. A large amount of blood, exudate, and ragged tabs of dead or devitalized tissue can be removed, which otherwise, by infiltration of the muscles and soft parts, and by autolysis and the local accumulation of autolysates, would result in slower functional return in the soft parts, and slower healing at the fracture site. A fractured shaft of the femur, operated upon within the first few hours, has frequently been shown to be accompanied by the presence in the surrounding tissue, and about the bone, of one to one and one-half liters of such an admixture of blood, oedema fluid, and exudate. The absorption of this material definitely adds to and maintains the state of shock present in the patient. In clinical follow-ups, early operation in itself has been demonstrated to have definitely and favorably influenced the speed of convalescence and the quality of the late results.

The general condition of the patient, extremely and habitually dirty skin, and other factors may make such early operation inadvisable or unfeasible. When this is so, every measure possible should be used to disperse this local infiltration of the tissues, and operation should be performed as soon as a return to relatively normal tissue consistencies can be demonstrated. This may take from two to ten days, depending upon the pathological changes present and the efficiency of the measures used.

The Skin

The preparation of the skin should be carefully carried out, and should accomplish

* Read at the Annual Meeting of The American Academy of Orthopaedic Surgeons, Chicago, Illinois, January 25, 1944

surgical cleanliness without trauma. The part should be kept under traction or other form of fixation while this is being done. We employ manual traction in most instances. We do not use skin antiseptics; soap and water, followed by alcohol and ether are preferred. We use gauze sponges, and employ lots of time, soap and water, alcohol and ether, and not too much vigor. The area so cleansed is extensive,—in the tibia, for instance, from the toes to well above the knee joint.

Traction or other form of fixation should be maintained while the draping is being carried out. The draping should be so done as to allow free movement of the extremity, and should aim at complete exclusion of the skin surface and skin edges from the operative field. In the upper extremity the hand, if it is not involved, is covered by a sterile flannel bag, bandaged on. In the lower extremity, the foot is similarly dealt with. If the wrist and metacarpals are involved, the fingers are encased in a rubber glove, bandaged on. If the foot or ankle is involved, the toes are similarly excluded. Drapes are then applied to leave exposed only the operative area. Traction employed steadily during these procedures spares the parts considerable additional trauma.

Two pairs of gloves are worn by the operator, his assistant, and the nurse who does the draping. The draping is finished by clipping towels to the wound edges so as to exclude them, as well as the skin surface, from the operative field, as soon as the incision is made.

The skin incision should be generous,—as long as it is feasible to make it. The longer the incision, the less trauma from retraction, the better the exposure, the easier the reduction, and, in many instances, the better the wound healing, and the less the risk of infection. Wounds heal from side to side and not from end to end.

The skin incision should not be placed over subcutaneous bony surfaces, if it is possible to avoid them.

In making the skin incision, the hands do not handle the skin. It is handled by gauze pads, held in hemostats or forceps. As soon as the skin incision has been made, superficial bleeders are clamped with mosquito clamps; only the tip of the clamp is used, so as to avoid damage to the tissue; and as fine a ligature material as possible is employed, silk being used in clean cases. The towels are then clipped to the wound, as described, and every effort is made to avoid contamination of the exposed surfaces by skin during the process.

The Deeper Layers

When this has been accomplished, the outer gloves are removed, leaving the hands covered by the inner ones, which have been protected up to now from contact with skin or anything which has touched skin. All the instruments used up to this point are then discarded, and a new set-up is utilized.

A word here about the "no-touch" or Lane technique. The Lane technique involves the carrying out of the operative procedure without ever putting into the wound anything which has touched skin or the draping about the wound. The fingers are never put into the wound. An instrument or a suture which has touched draping is theoretically contaminated and should be immediately discarded. The absolute carrying out of the provisions of "a Lane" is impossible. No operation can be done without the occasional necessity for violating such a rigid technical demand, or without minor infractions. A close approach to it can be accomplished, if the same well-trained and practised team works together over a period of years. When a shifting personnel is employed, the attempt to carry out a rigid Lane technique results in loss of time and clumsiness of procedure which offsets its value. It is, however, essential that there be recognition of the fact that operative reductions of fresh fractures call for a particularly careful technique, if the risk of infection is to be minimized. The author believes that, in the average situation, the demands can be met, if a maximum of gentleness and a minimum of tissue damage are made the criteria for each procedure, and if the operator and his assistants cultivate the idea that

the whole operative field, the instruments, and their hands are contaminated, and that their job is to introduce as little of that contamination into the wound as possible, and to leave the tissues in optimum condition to deal with what contamination is introduced. The freedom with which instruments and hands are unnecessarily poked into and moved around in wounds would be materially diminished if that viewpoint could prevail. The author believes that, with this viewpoint, and with the occasional aid of an observer who reports on the frequency with which unnecessary potential wound contamination and wound trauma occur, a satisfactory, although not ideal, approach to the idea of a Lane technique is possible.

It is in keeping with such an idea that meticulous hemostasis be employed throughout the procedure, utilizing small, fine clamps and fine ligature material; that, where possible, vessels be clamped and ligated before cutting; and that, where possible, exposure be accomplished by sharp dissection rather than by blunt dissection.

The approach to the fracture site should be accomplished wherever possible through intermuscular planes, and not by cutting through muscle bodies. Almost every fracture can be so approached for the most part, if not altogether. In making this approach, the plane should be opened up by sharp dissection in the axis of the incision, with a minimum of lateral stripping, until the periosteum is reached. It is here that the value of the long incision first becomes apparent, allowing the tissues almost to fall apart, and avoiding the necessity for forceful lateral retraction.

The Periosteum

When the periosteum has been reached throughout the extent of the incision, exposure of the fracture site should be accomplished by splitting the periosteum and exposing each fragment subperiosteally, and *not* by stripping the soft parts from the periosteum. The exposure must be extensive enough to provide adequate space for visualization of the fragments, for the placement of clamps for reduction, for the placement of fixation elements of adequate length and for holding them in place during their application, and for the necessary cross fixation by screw. If this is attempted by stripping the soft parts from the periosteum, the circulatory supply of the periosteum will be destroyed, since that circulation comes from the attached soft parts, and not from the bone. If those soft parts are stripped away, the periosteum constitutes an avascular membrane interposed between the bone and the surrounding soft parts. When the exposure can be accomplished subperiosteally the circulation to the periosteum is preserved, and, when the soft parts *en masse* are put back again over the reduced fracture, vascular tissue is in contact with bone surface and fracture site. Objection can theoretically be raised to such extensive subperiosteal exposure, but we are firmly convinced that inadequate exposure is one of the reasons for failures in open reductions and fixations, because of poor visualization and the trauma and difficulty of manipulation and application of fixation. It would be ideal if no stripping of any tissue were necessary. What stripping is necessary should be subperiosteal, the elevator being used not as a scraper, but as an elevator or lifting implement, every effort being made to keep the periosteum intact. Unnecessary stripping should, of course, be avoided. Only such aspects and areas of the fragments should be exposed as are necessary for accurate reduction and for the application of adequate fixation. This degree of stripping is to be regarded as necessary; and, in our experience, if performed as described, has no ill effects on fracture healing. Every attempt is made to preserve the soft-part attachments of any loose fragments in fastening them to the main fragments. If, however, in a clean case, one is faced with the problem of whether or not to strip the soft-part attachments of a fragment loose at the fracture site, and the fragment is necessary for rigid fixation, it is preferable to strip those attachments as much as necessary to accomplish the purpose of rigid fixation. Such stripping should be only as much as necessary, and, again, should be subperiosteal.

Traction should be maintained on the foot or on the hand by an assistant throughout the operative procedure until the fixation is accomplished. This maintenance of traction materially reduces the amount of instrumental violence necessary to obtain reduction.

The Bone

When exposure has been accomplished, the mechanical problem is evaluated, and reduction is carried out by the use of skids or clamps as indicated. It is here that a large variety of clamps and skids is of great help in meeting mechanical demands with a minimum of violence and a maximum of efficiency. When reduction has been accomplished (and this should be as near hairline as possible, without distraction of the fragments, and demonstrably accurate on all faces of the bone), it should be held by the application of a clamp or clamps. Here again a wide variety of clamps is a great help. When the fracture line is practically transverse, this is sometimes difficult to accomplish, and may result in an unsteady fixation with any clamp or combination of clamps. Under those circumstances an alternative procedure described below is resorted to.

The holding clamp or clamps are so placed that the face of the bone chosen for the application of the plate, by reason of the mechanical situation at the fracture site, is free. A plate is then chosen. It should be heavy enough for the bone involved, and should be about five times the length of the bone's diameter at the fracture site. Less than that is undesirable; more is unnecessary. If a plate of that length cannot be used because of the situation of the fracture, one as near that length as possible should be utilized. It should, if possible, be a six-screw plate, and never less than a four-screw plate. It should be molded to fit the contour of the bone when placed so that its center corresponds to the center of the fracture line. This molding is best done by using aluminum bending tools which, being soft, do not scratch the plate. If steel clamps are used for this purpose, they should be rubber covered to protect the plate surface from damage.

The plate is then placed *in situ*, and is firmly held to the bone by one or more clamps. Here again, a variety of available clamps sufficient to meet the mechanical demands is helpful. The holes for placing the screws are now drilled, each screw being placed before the hole for the next one is drilled. The drill should be just a shade smaller than the shank of the screw minus its threads. This is extremely important. If it is too large, the screw does not cut sharp deep threads, and loses holding power. If it is too small, the screw meets such resistance in trying to cut threads that it may shear off. Even if it does not, the excessive shearing strain to which it is subjected during insertion may weaken it so that it will break later, and seriously complicate the progress of union.

The proper-sized drill for the screw used should be determined, and that size drill should always be used. It is wise to have a sterile, home-made gauge, consisting of a wooden or metal plate with a hole drilled through it by the proper drill, in the operating room, and to check the drill point against it before using. The hole must be drilled at right angles to the plate surface, and every effort must be made to keep the drill steady during the process. The choice of a proper drill and care in its handling are important. Every effort must be made to center the drill in the hole in the plate as accurately as possible. If the drill hole is badly centered, or if it is at an angle to the surface of the plate, not only are the screw threads apt to be stripped, but the abraded surface of the screw is apt to give rise to severe reaction with absorption of calcium about it, which results in loosening. The drill holes should go through both cortices of the bone.

When the drill hole has been made, it has to be tapped either by a tap or by the use of a self-tapping screw. If the latter is used, and this is the common practice, the tapping device must have accurate right-angled, milled, cutting edges with a clearance for the bone powder created by the tapping, and must cut clean, deep threads. We use a machine screw with a self-tapping point. The threads are sharp; they do not have to be extremely deep if they are sharp and the tap is good. Each screw has to stand individual inspection

with a glass. The screw is inserted in the line of the drill hole. Every effort must be made to keep the screw from wobbling during its insertion and to avoid a reaming action. We use a special screw driver that automatically centers the screw and holds it rigid. No matter what method of inserting the screw is used, the precautions stated must be observed. Steady, firm pressure is used while the screw is cutting the threads in the proximal cortex. Once that is accomplished, the screw runs through these threads with little or no resistance, until it meets the opposite cortex. Firm pressure is again needed to cut threads in the far cortex. As soon as the screw has done this, it again runs easily. It should protrude through the far cortex only by the length of its tap. A simple but accurate way of measuring the length desired for the screw is to mark the drill point by a clip or a clamp at the proximal cortex at the moment when it is felt first to bind, and then to go through the opposite cortex. If, as soon as the bind is felt, one drills slowly, the drill can be halted as soon as it suddenly ceases binding. Another simple method is to use a wire with a sharp bend at its end, like a crochet hook, with a sliding sleeve about the wire. The wire is pushed through the drill hole, and then pulled back until the crochet hook catches on the far cortex. The sleeve is then slid down until it is in contact with the near cortex, and is fixed there with a set screw; the wire is withdrawn, giving the exact length desired.

All six screws are so applied before any of the fixation clamps are removed. It is occasionally necessary to shift one of the clamps holding the plate in order to get at the holes in the plate. Before the clamp is shifted, another one is applied, which will take its place when it is removed.

The clamps holding the plate are then removed, the ones holding the fracture are left *in situ*. A hole is then drilled on a plane at a right angle to the plane of the screws holding the plate, so as to go from one fragment, across the fracture line, and out through the other fragment. If the fracture line is oblique or spiral, this hole can be driven straight across the fracture line. If the fracture line is transverse, the drill hole has to be made obliquely across the fracture line from one fragment to the other, and counter sinking for the screw head is indicated to avoid shearing strain. A screw is then inserted through this drill hole. This screw serves to take up torsional strain and eliminate torsional mobility at the fracture site, and to take this strain from the plate and its screws, thus distributing the strain. A second similar screw can be applied if necessary. It should be here emphasized that the placing of this transfixion has proved, in our experience, to be a vital factor in securing rigidity of fixation and distribution of strain. With its use, the difficulties due to loosening of screws, breakage of materials, and reaction to the fixation metal have been reduced to a minimum, and visible absorption at the fracture site has been eliminated in clean cases. In our experience late absorption at the fracture site with a visible gap—so-called distraction—in the vast majority of cases results from only two causes,—infection or movement of the fragments at the fracture site. The latter is frequently present when a plate alone is used, and may result in absorption. The cross fixation is our guarantee against this. It is a most valuable and, in our opinion, necessary feature of the fixation.

The clamps are now removed and the fracture is tested for rigidity of fixation. If an additional transfixion screw is needed, it is applied.

The soft parts, with the attached and vascular periosteum, are then placed back over the bone and the fracture site, and are sutured with multiple, interrupted, fine silk. The towels are then removed from the skin edges. Fresh towels are placed about the wound, and the skin is closed with interrupted fine silk or dermal sutures.

When difficulty is encountered in holding the fracture reduced—principally in transverse fractures—the position for the plate may be determined, and it may be fastened to one fragment by the technique previously described. The fracture is then accurately reduced, and the remaining portion of the plate can be used to maintain reduction through clamps fixing it to the other fragment while the remaining screws are applied. The cross fixation is then inserted.

When a loose fragment is present, it should be accurately reduced to one or the other of the main fragments and fastened by screws to assemble the bone into two fragments. These are then plated by the technique described, and the intermediate fragment is then transfixed to the other main fragment.

Two different metals should never be used in plating. As pointed out by Venable, the use of two different metals simultaneously may lead to considerable reaction, with absorption about the fixation units and loss of immobilization and position, which results in delayed union or non-union.

Plates and screws should be made from a metal which is physiologically inert in the tissues when and if firmly fixed, and if not subjected to intensive strain on any single one of its elements. We use plates and screws made of the so-called "19 and 9 chrome-nickel stainless steel", or made of the so-called "18 and 8 SMO stainless steel". Both have proved satisfactory with regard to the above criteria, and, when properly applied, both are able to stand the strain imposed by muscle forces without undergoing fatigue strain or fracture. Vitallium and other metals are said to satisfactorily meet the same criteria. Authoritative and exhaustive investigations now under way will present evidence in the near future as to the relative ability of these various metals to meet the demands outlined above, and as to advisable methods of manufacturing the plates and screws.

RESECTION OF THE DISTAL END OF THE ULNA

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It is the purpose of this paper to discuss the conditions in which the distal end of the ulna can be resected to advantage, the indications for the procedure, and the results which can be expected from its use.

Resection of the lower end of the ulna is useful in correcting deformities of the wrist where radial shortening has occurred. It may be indicated to relieve symptoms arising from pathological conditions in the distal radio-ulnar joint. In the former category are: malunited Colles's fractures with radial shortening; ununited fractures of the radius with radial shortening; and premature ossification of the lower radial epiphysis with overgrowth of the ulna. In the latter category are: arthritis or ankylosis of the distal radio-ulnar joint; laxity of the distal radio-ulnar joint with recurrent subluxation; old dorsal dislocation of the lower end of the ulna; and Madelung's deformity. Improvement in, or restoration of, pronation and supination usually results in either group.

In malunited Colles's fractures, with considerable shortening of the radius due to impaction of the fragments, the lower end of the ulna is prominent, and the normal relation of the radio-ulnar joint no longer exists. Osteotomy of the radius will correct the deformity in this bone, but may not restore the normal radial length or the normal relationship in the distal radio-ulnar joint. In such a case, resection of the lower end of the ulna will eliminate its protrusion, and prevent the development of traumatic arthritis in the distal radio-ulnar joint; it will also correct the fixed radial deviation of the hand, and permit normal ulnar deviation of the wrist.

In comminuted fractures of the lower end of the radius, radial shortening is often present. A disturbance of the distal radio-ulnar joint may occur, if the fracture enters the joint. If a reasonably normal relationship in the joint cannot be restored, or if the radial shortening cannot be overcome, resection of the lower end of the ulna should be done. This will improve the external contour of the wrist, and will ensure better function.

In ununited fractures of the radius, not associated with fracture of the ulna, radial shortening occurs. Where this shortening is marked, a secondary dislocation of the lower end of the ulna may develop. If this condition is of long standing, resection of the lower end of the ulna is usually indicated. In cases of non-union of the radius, the soft tissues may contract to the extent that the radial shortening cannot be corrected at operation, even after thorough mobilization of the radial fragments. Under these conditions, there arises the problem of bridging the defect in the radius, in order to restore radial length or of bone-grafting the radius after the two fragments have been brought into apposition. The latter is the simpler and usually the better procedure, but radial shortening results, necessitating resection of the lower end of the ulna in order to obtain a good cosmetic and functional result.

Premature ossification of the distal epiphyseal line of the radius may be the result of trauma or disease,—such as traumatic separation of the radial epiphysis, or infection involving the epiphyseal line. If the growth of the lower radial epiphysis is retarded or stopped, the ulna outgrows the radius along the dorsal or medial aspect of the wrist. The excessive ulnar length limits dorsiflexion, ulnar deviation, and supination of the wrist, and results in an unsightly deformity. Resection of the lower end of the ulna offers a simple method of correcting the deformity, and permits normal motion in the wrist.

In arthritis of the radio-ulnar joint, pronation and supination are painful and usually restricted. The pain often results in muscle weakness in the hand. If the pain and limi-

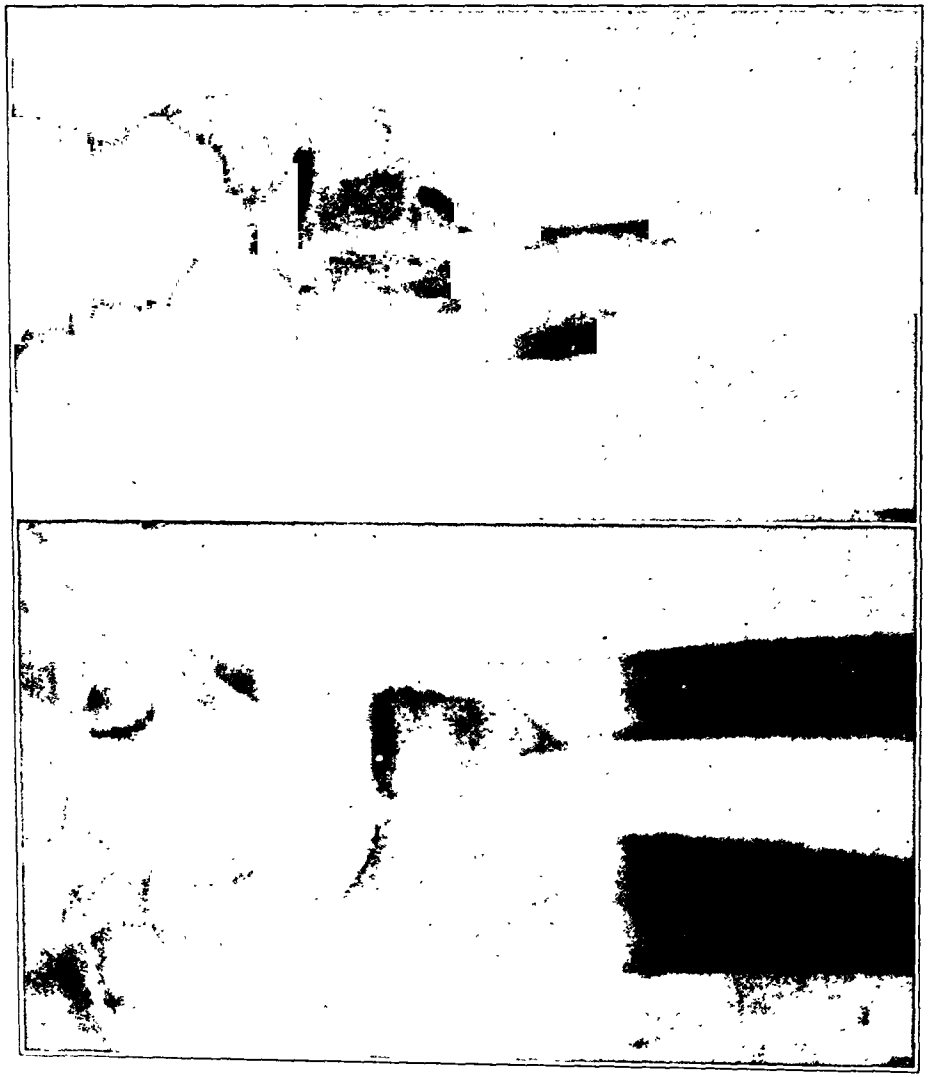

FIG. 1-A

Illustrates a compound comminuted fracture of the lower end of the radius, in a cast, as first seen at the Clinic. The fracture occurred three and a half weeks before.

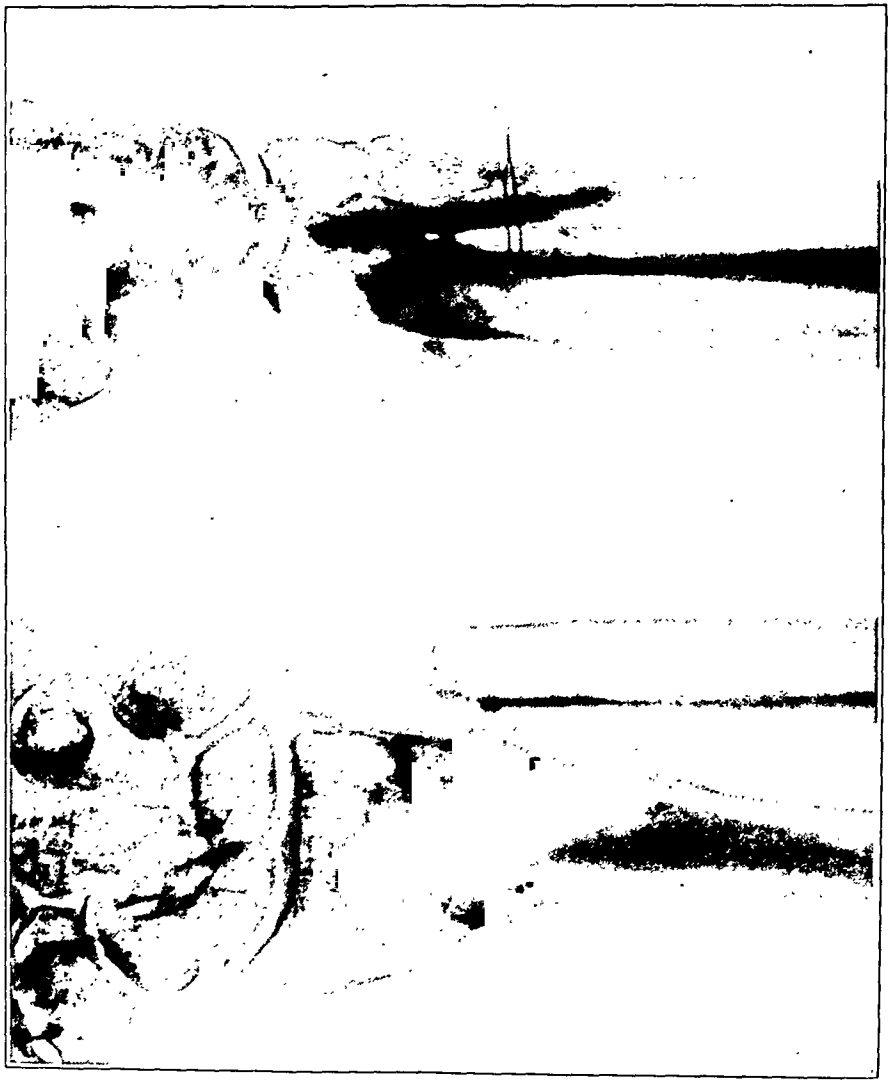

FIG. 1-B

Shows the appearance of the wrist nine months following reconstruction of the wrist and resection of the lower end of the ulna.

FIG. 2-A

Shows the bones of the wrist two months following a compound comminuted fracture of the lower end of the radius and ulna, involving the wrist joint.

FIG. 2-B

Illustrates the condition of the wrist five and a half months following reconstruction of the lower end of the radius and excision of the lower end of the ulna. This patient obtained a good end result.

tation of motion are severe enough to handicap the patient in his work, resection of the lower end of the ulna is indicated. The operation will relieve the pain, as the painful joint is removed. Pronation and supination are usually materially improved and may return to normal, and the apparent weakness in the hand improves.

In ankylosis of the distal radio-ulnar joint, pronation and supination are absent. In order to restore these motions, an arthroplasty of the joint, or resection of the lower end of the ulna, is necessary. Resection is by far the simpler procedure, and the end results are better, as arthroplasties of the smaller joints are usually unsatisfactory.

In laxity of the distal radio-ulnar joint, associated with recurrent subluxation, arthritic changes due to the trauma usually develop. This painful condition has been treated by a fascial loop around the lower end of the ulna to secure it to the radius. This will stabilize the distal radio-ulnar joint, but will not eliminate the arthritic changes. Limitation of pronation and supination may follow the operation, as a result of fibrosis and the consequent inability of the ulna to rotate smoothly in the fascial loop. It may be better to resect the lower end of the ulna, especially if the condition is of long standing, and definite arthritic changes have occurred.

In persistent dorsal dislocation of the lower end of the ulna, of six weeks' duration or longer, a resection of the distal end of the ulna is the procedure of choice. Reduction of the dislocation is usually not feasible, because of degenerative changes which have occurred in the articular cartilage. Furthermore, if the dislocation is reduced, some method to prevent redislocation is necessary,—such as the fascial-loop operation used in laxity of the distal radio-ulnar joint. The disadvantages of this procedure have already been stated.

In the correction of Madelung's deformity, resection of the lower end of the ulna may be used in conjunction with an osteotomy of the lower end of the radius.

In severe flexion contracture of the wrist, as seen in Volkmann's contracture or in untreated rheumatoid arthritis, fusion of the wrist is occasionally indicated. In order to correct the flexion deformity, partial resection of the carpus and lower end of the radius may be necessary. Resection of the lower end of the radius will result in excessive ulnar length and require resection of the lower end of the ulna. With this procedure, pronation and supination are possible, following fusion of the radius to the remaining portion of the carpus. Arthrodesis is aided by using the resected bone as a graft, either through a second dorsolateral incision or through the same incision, as described by Smith-Petersen.[4]

OPERATIVE TECHNIQUE

Resection of the lower end of the ulna is not a difficult procedure and can be carried out through a longitudinal incision over the dorsomedial aspect of the ulna. In this region the ulna is subcutaneous. The bone is exposed subperiosteally from the styloid process to approximately one-half inch above the level at which the resection is to be done. This level depends upon the condition for which the bone is being resected. Care should be taken not to excise the ulna above the upper level of the origin of the pronator quadratus. By leaving the major portion of the origin of this muscle, fair stability of the lower end of the ulna is assured. The level of resection is usually about an inch above the tip of the styloid process. Three or four holes are drilled with a small drill point through the ulna at the level selected for resection. The bone can then be divided with sharp bone-biting forceps. Crushing of the bone is avoided by making multiple small cuts with the bone-biting forceps, connecting the drill holes. Following completion of the osteotomy, the ulnar fragment is grasped with a Kocher clamp just distal to the site of osteotomy, and, while gentle traction is applied, the bone is separated from the periosteum with a periosteal elevator. When the styloid process is reached, its attachments to the triangular articular disc and ulnar collateral ligament are divided, completing the removal of the lower end of the ulna. The wrist joint is not opened, as the articular disc is not removed.

The osteotomy of the ulna can be accomplished with a Gigli saw, although this method

FIG. 3-A

Shows a radial shortening in a boy fourteen years of age, as a result of epiphyseal separation of the lower end of the radius at the age of nine.

FIG. 3-B

Shows the result one month following resection of the lower end of the ulna.

FIG. 3-C

Shows the result three years following operation. Note the remodeling of the lower end of the ulna, resulting from use during this period.

requires wider exposure and is a little more time-consuming. An osteotome can be used for this purpose, but the bone-biting forceps are preferable, as there is less chance of splintering the bone or of damaging neighboring structures.

After removal of the bone, its periosteal sheath should be collapsed. The ulnar collateral ligament and the periosteum form a ligament connecting the distal end of the ulna with the medial side of the wrist. After hemostasis has been secured, the remaining dead space should be obliterated by closing the surrounding soft tissues with interrupted sutures. These precautions help to prevent calcification in the space from which the bone has been removed. The subcutaneous tissue and skin are closed in routine manner. Postoperative immobilization may or may not be indicated, depending upon the condition for which the resection has been done.

CASE REPORTS

CASE 1. L. A. L., No. 57648, a male, aged sixty-two, illustrates a compound comminuted fracture of the lower end of the radius of three and a half weeks' duration. The compound wound had healed without infection. Figure 1-A illustrates the position of the fragments in a cast when the patient was first seen at the Clinic. At this time there was a persistent silver-fork deformity; the fingers were moderately swollen; and there was marked limitation of motion in the small joints of the hand.

A reconstruction of the wrist was done. At operation it was found that the radial shortening could not be satisfactorily corrected, due to contracture of the soft tissues. The distal one inch of the ulna was excised. Following this, the fracture of the radius could be reduced. This reduction was maintained by a homogenous bone graft and one small stainless-steel wire suture.

Four months following the operation, the external contour and appearance of the wrist were excellent. The resected end of the ulna was satisfactorily anchored in the soft tissues; it was stable and not painful; supination of the wrist was 80 per cent. of normal, and pronation was normal. Figure 1-B shows the appearance of the bone nine months after operation. This patient has an excellent cosmetic result and a good functional result, considering the initial soft-tissue damage.

CASE 2. J. H. C., No. 55786, a male, aged twenty-four, fell forty feet from a scaffold and sustained multiple injuries, including a compound comminuted fracture of the lower end of the radius and ulna, involving the wrist joint.

Figure 2-A shows the condition of the bones of the wrist two months following the injury. At this time a reconstruction of the lower end of the radius was done, and the distal one and one-fourth inches of the ulna was resected. Figure 2-B illustrates the condition of the wrist five and a half months after the operation. At this time, supination of the wrist was 80 per cent. of normal; pronation was normal; dorsiflexion of the wrist was 80 per cent. of normal; palmar flexion, 75 per cent. of normal; and radial and ulnar deviation of the wrist were normal. The patient stated that the wrist was painless, except for slight aching at times. The cosmetic result was excellent. Four months after this examination the patient was inducted into the infantry.

CASE 3. B. C., No. 32181, was fourteen years of age when he was first seen at the Clinic. He gave a history of an epiphyseal separation of the lower radial epiphysis at the age of nine. Since that time there had been a gradually increasing deformity of the wrist and limitation of motion.

Figure 3-A shows the relative increase in the length of the ulna, due to retarded growth at the distal epiphyseal line of the radius. The patient's chief complaint was the apparent overgrowth of the ulna and inability to supinate the hand. The lower one and one-fourth inches of the ulna was resected. Figure 3-B shows the result one month following this operation. Figure 3-C shows the result three years following the operation. The remodeling of the lower end of the ulna, secondary to use during this period of time, is of interest. The strength of the wrist at this time was practically normal. There was a slight amount of weakness in the grip of the little and ring fingers, as compared to the opposite side. There was a normal range of motion in the wrist in all directions, except pronation, which was 90 per cent. of normal. The forearm was approximately one and one-half inches shorter than normal, while the humeri were the same length.

CASE 4. O. R., No. 59369, a male, aged twenty-eight, illustrates a resection of the lower end of the ulna for degenerative changes in the distal radio-ulnar joint following trauma. He sustained a compound fracture of the right forearm seven months before admission to the Clinic; there was drainage from the wound for approximately six weeks. At the end of this time the wound healed and there was no further drainage. The patient's chief complaint was pain over the lower radio-ulnar joint and inability to pronate and supinate the hand. Examination revealed a moderate amount of volar bowing of the radius approximately three inches above the wrist, secondary to the healed fracture of the radius at this level. The forearm was in the neutral

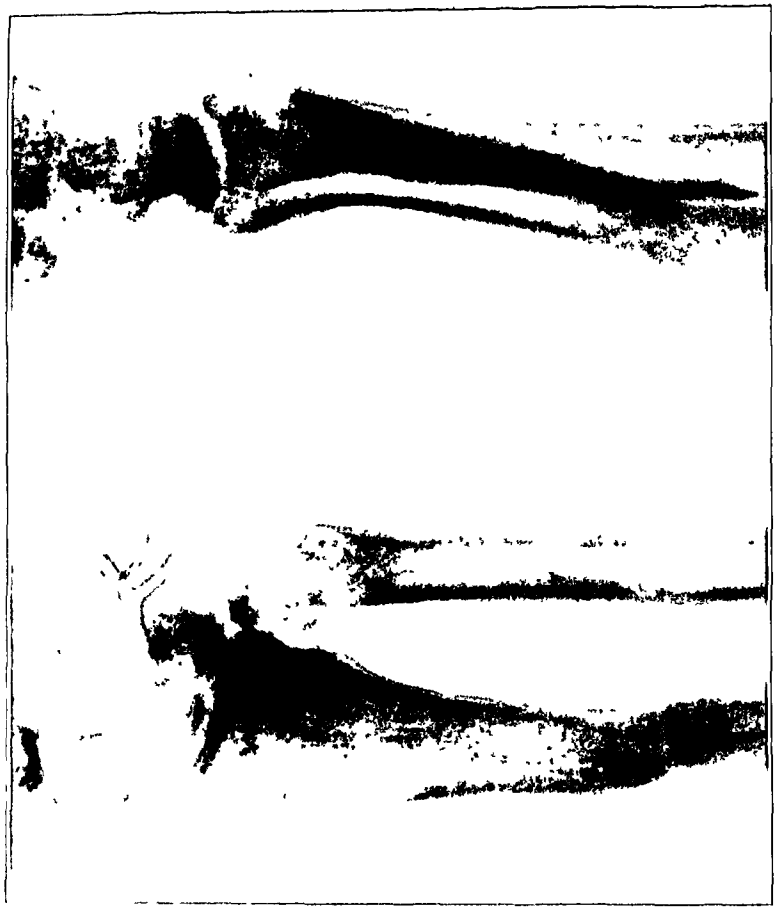

FIG. 4-A

Illustrates degenerative changes of the distal radio-ulnar joint following trauma.

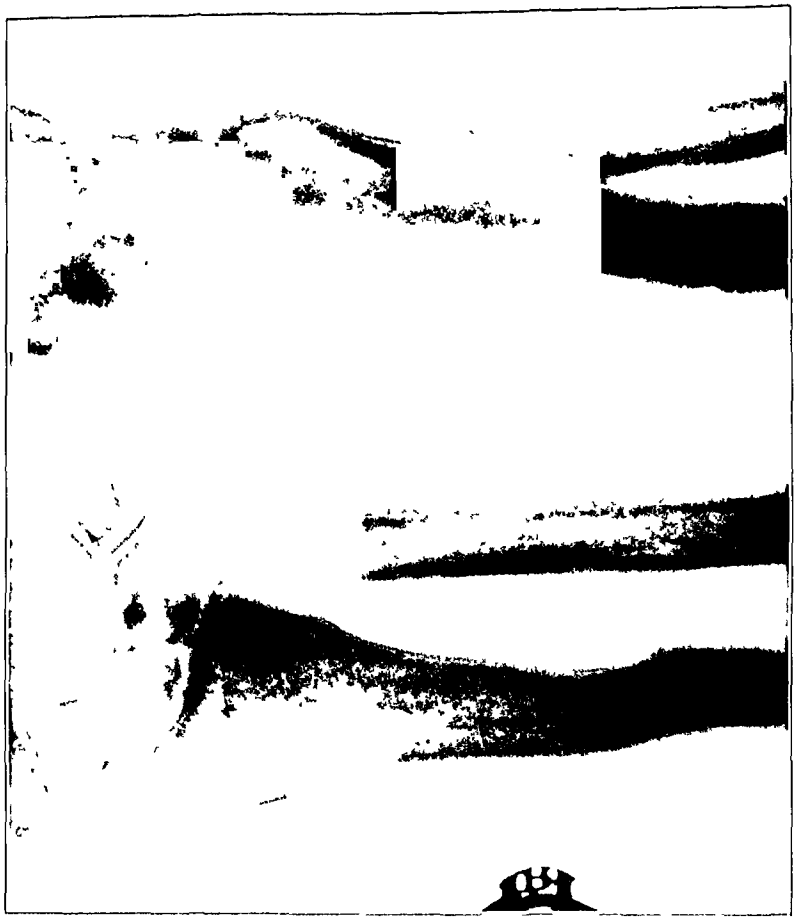

FIG. 4-B

Shows the appearance of the wrist a month and a half after resection of the lower end of the ulna.

position, and there was approximately 15 degrees of pronation from this point. This motion caused pain over the distal radio-ulnar joint, and passive motion caused pain and crepitation.

Figure 4-A shows degenerative changes in the distal radio-ulnar joint. Figure 4-B shows the wrist a month and a half after resection of the lower end of the ulna. At this time the pain in the distal radio-ulnar joint had disappeared. There was practically normal supination, and pronation was 50 per cent. of normal. This patient may obtain more pronation with time and use, but in all probability he will have some permanent limitation of pronation, due to the angulation of the radius, resulting from the original fracture.

CASE 5. J. H., No. 60339, a male, aged forty-two, illustrates the result following resection of the distal end of the ulna for persistent posterior dislocation of the distal radio-ulnar joint. Two and a half months before operation the patient was pushing a heavy boiler which accidentally rolled over his hand and forearm. Before operation the patient's chief complaint was pain in the distal radio-ulnar joint; motion of the wrist was 75 per cent. of normal. The forearm was in full pronation and could be supinated passively to mid-position but no farther. The lower end of the ulna was prominent on the dorsal aspect of the wrist. There was crepitation between the lower end of the ulna and the radius.

Figure 5-A shows a dorsal dislocation of the lower end of the ulna. This appearance is not due to rotation of the wrist, as the roentgenogram shows the radiocarpal joint in its true lateral projection. Figure 5-B shows the appearance of the wrist following resection of the lower end of the ulna two and a half months after the operation. At this time the patient had normal active pronation and supination; motion in the wrist was normal in all directions, except radial deviation, which was 75 per cent. of normal. The cosmetic result was excellent. The pain in the distal radio-ulnar joint had been relieved. The grip in the left hand was practically normal. The patient was doing his regular work as a section hand on the railroad.

RESULTS

The results which follow resection of the lower end of the ulna have been satisfactory and better than our original expectations. Cotton and Morrison reported a case with an excellent end result; they stated that good results had been obtained in other patients, but did not report the number of cases. Other authors have reported the results following partial resection of the lower end of the ulna.

FIG. 5-A

FIG. 5-B

Fig. 5-A: Illustrates a dorsal dislocation of the lower end of the ulna. This is a true dorsal dislocation and the appearance in the roentgenogram is not due to rotation. The radiocarpal joint is shown in its true lateral projection.

Fig. 5-B: Shows the appearance of the wrist two and a half months following resection of the distal end of the ulna.

In 1937, Campbell reported an operation for the correction of malunited Colles's fracture, which gave good cosmetic and functional results. The prominent dorsomedial portion of the distal end of the ulna was removed. An osteotomy of the lower end of the radius was used to correct the deformity in this bone. Radial length was increased by placing the bone removed from the lower end of the ulna in the osteotomy of the radius. This operation does not remove the distal radio-ulnar joint, and may be used when there is no arthritis in this joint, and in patients without excessive radial shortening.

Hucherson reported two cases in which the Darrach operation was used to correct derangement in the distal radio-ulnar joint. In this operation the lower end of the ulna is resected, but the styloid process is not removed. It is left as a pseudosesamoid bone in the ligamentous structure formed by the periosteum and the ulnar collateral ligament. The advantages of this procedure over total resection of the lower end of the ulna are questionable. However, the end results in the two operations should compare favorably.

Members of the staff of the Campbell Clinic have excised the lower end of the ulna in twenty patients; two of these were bilateral cases, making a total of twenty-two resections. The end results obtained following this operation depend upon the condition for which the procedure is carried out. In no case did resection of the lower end of the ulna increase the disability of the wrist. In all patients, in whom radial shortening was present, the cosmetic appearance of the wrist was improved. In patients without radial shortening, the absence of the head of the ulna is more noticeable, as no deformity is present before the operation. The absence of the head of the ulna alters the appearance of the wrist, but this is of little cosmetic importance. The muscle power in the wrist and the grip in the hand are slightly diminished, but to a degree much less than one would expect. Motion in the wrist, especially pronation, supination, ulnar deviation, and, in some cases, dorsiflexion, is improved.

Degenerative changes in the distal radio-ulnar joint are painful and often constitute a major disability, preventing the patient from carrying out his regular work. This pain also produces an apparent muscle weakness in the hand and wrist. Resection of the lower end of the ulna in such a patient will relieve the pain, and the apparent muscle weakness will disappear.

CONCLUSIONS

1. The lower end of the ulna can be removed without materially affecting the strength and stability of the hand or wrist.

2. If the external contour of the wrist is essentially normal, resection of the lower end of the ulna produces little change in the appearance of the wrist. If a deformity of the wrist due to radial shortening is present, the cosmetic appearance of the wrist is definitely improved following resection of the lower end of the ulna.

3. The operation is not difficult to perform, and is useful in a variety of conditions. The procedure is especially valuable to restore or increase pronation and supination in the distal radio-ulnar joint, and to relieve pain caused by arthrosis in this joint. It is also useful in correcting deformity of the wrist secondary to radial shortening.

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BLASTOMYCOSIS OF THE SKELETAL SYSTEM

A Summary of Sixty-Seven Recorded Cases and a Case Report

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In July 1894, Busse reported bacteriological studies upon purulent material from a tibial abscess of a German woman, thirty-one years old, who also had generalized lesions. His investigations revealed a yeastlike fungus which, when treated with sodium bicarbonate, appeared microscopically as double-contoured, refractile bodies. It is of orthopaedic interest that this case was the second reported of the condition now universally recognized as blastomycosis; the first, a patient with skin lesions, was reported by Gilchrist in June 1894. Since that time, numerous cases have been reported; but, because of the incomplete knowledge of the bacteriology and serology of this disease, even at the present time all of these cases cannot be diagnosed with certainty to be caused by the same fungus. Furthermore, it is unfortunate that in many of the recorded cases, inadequate roentgenographic, pathological, and bacteriological studies have been made. Because of this, some of the cases of generalized blastomycosis may have had involvement of the bones and joints which was unrecognized. Therefore, these cases are not included in this summary. In 1939 Martin and Smith[8], and in 1941 Jones and Martin published excellent reviews of the literature on blastomycosis of the bone. These included comprehensive discussions of the etiology, mycology, pathology, diagnosis, symptomatology, prognosis, and treatment of this condition. The reader is referred to these articles for further information. In this study, the authors wish to summarize the sixty-seven cases of blastomycosis involving the bones and joints, reported to date, and to add a case that recently was seen on the Orthopaedic Service of the Hospital of the University of Pennsylvania.

Blastomycosis involving the skeletal system is usually found in cases with generalized infection. In one review[8], about 50 per cent. of the 243 proved and presumptive cases of generalized blastomycosis had bone and joint involvement. The age incidence in systemic blastomycosis ranges from six months to seventy years, but over 50 per cent. of the cases reported were between twenty and forty years of age. The sex distribution shows that the male is more frequently infected than the female, in the ratio of about nine to one.

Of the sixty-seven recorded cases, the location of the skeletal lesions is given in Figure 1. It is evident from this that the structures most commonly involved were in order as follows: vertebrae, skull, ribs, tibia, tarsus, knee, metatarsus, and carpus.

The mortality in cases of skeletal blastomycosis, as far as can be determined, is about 89 per cent. Recoveries were reported in only seven of the sixty-seven cases in this summary.

The diagnosis of blastomycosis is unequivocally confirmed only by the isolation and identification of the fungus, blastomyces dermatitidis. A tentative diagnosis can be made, however, by means of a complement-fixation test, as described by Martin and Smith[8], and by a skin test, using heat-killed vaccine[5]. Since about one-half of the cases of systemic blastomycosis begin with an upper respiratory infection, the roentgenographic examination of the chest may be indicative. The roentgenographic appearance of

the skeletal system in this disease is not pathognomonic, but, according to Potter, the following observations are important:

"The combination of a sub-epiphyseal or sub-articular focus of an intensely localized character with a mature and homogeneous periosteal sheath around it" is commonly found in the long bones.

"Lesions of the spine show the same patchy appearance that is found in the short bones of the wrist. A marked destruction of the vertebral bodies may take place before a collapse of their substance occurs. This is probably due to the persistence of certain bony compartments immediately adjacent to the abscess cavity.

"Blastomycosis in any of the bones, when not accompanied by the periosteal reaction, shows a maximum of localized destruction with a minimum of porosis or partial decalcification in the neighboring bone."

In view of the high mortality of cases with skeletal blastomycosis, it is apparent that at present the treatment of this condition leaves much to be desired. Of the seven patients who have recovered, as reported to date, all had received a saturated solution of potassium iodide by mouth. Other therapeutic measures included: high-caloric, high-vitamin diet, heliotherapy, blastomyces vaccine, immune serum, neoarsphenamine, antimony and potassium tartrate intravenously, colloidal copper intramuscularly, irradiation to the local lesions, and maggots. Jones and Martin advocate the use of the skin test with blastomyces vaccine to determine the patient's allergic status. If a sterile abscess results, the patient should be desensitized with the vaccine before potassium iodide is given; and desensitization may have to be repeated, if an exacerbation of symptoms occurs during iodide therapy. Conservative measures are advised in the care of local lesions, until desensitization has been accomplished and iodides have been given. After this, surgery can be performed when indicated.

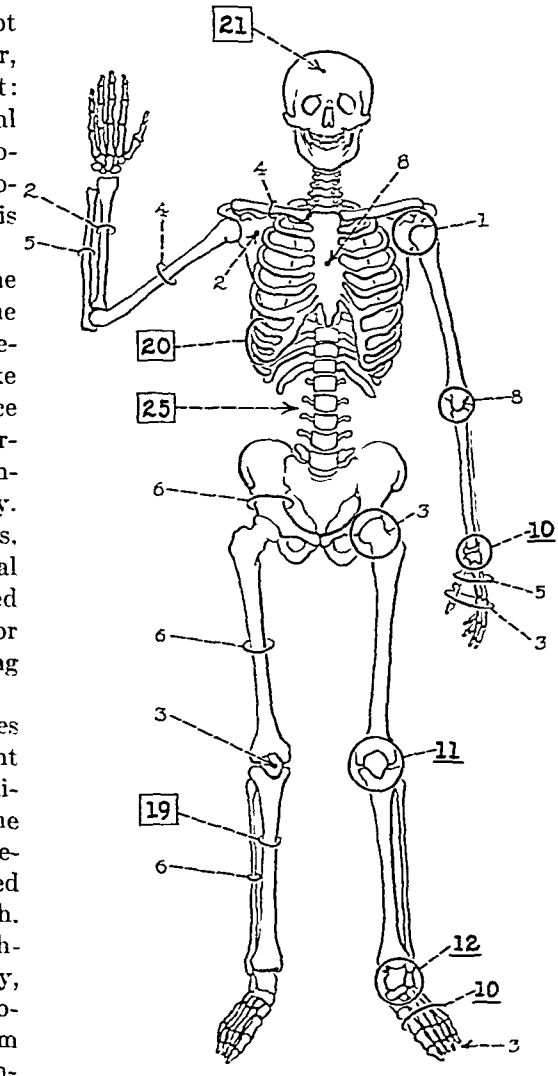

FIG. 1

The location and frequency of the lesions in the sixty-seven recorded cases of skeletal blastomycosis.

CASE REPORT

W. S., a negro laborer, thirty-six years old, was admitted to the Hospital of the University of Pennsylvania, July 18, 1942, with a chief complaint of pain in the left knee.

Family History: A sister had died of pulmonary tuberculosis. Syphilis was suspected in the family, but was not proved.

Past Medical History: At twenty-one and twenty-two years of age, the patient had had gonorrhoeal urethritis, and at thirty-four gonorrhoeal urethritis complicated by pyelonephritis, which had been treated with sulfanilamide. At thirty-five years of age, a diagnosis of pleurisy of the left upper lobe was made without roentgenographic examination. A routine Wassermann had been found to be positive, and intra-

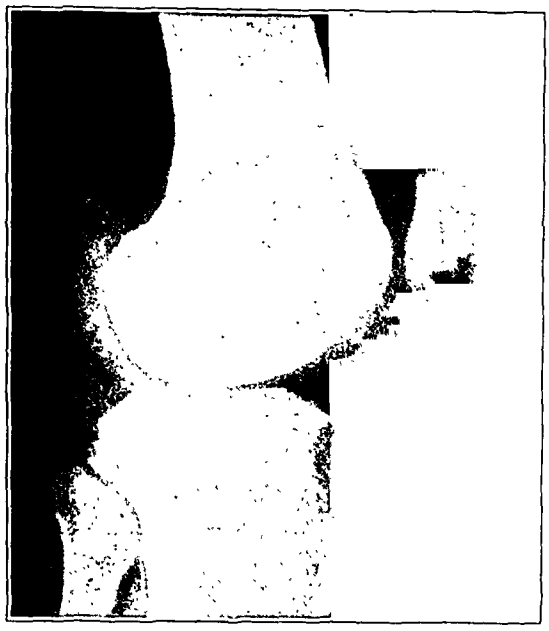

FIG. 2

Roentgenogram of the left knee, July 20, 1942, showing osteomyelitis of the left patella.

FIG. 3-A

Appearance of skin lesion of the left knee shortly after biopsy of the upper lip on August 20, 1942.

FIG. 3-B

Appearance of skin lesion of the face.

FIG. 3-C

Appearance of skin lesion of the right wrist.

muscular injections of bismuth had been started, but subsequent treatment had been irregular. At thirty-six years of age, he had complained of back pain, and a diagnosis of cystitis and obstructed ureter had been made, and urotropin had been used. "Impetiginous" skin lesions of face and buttocks had been noted.

Present Illness: In June 1942, at the age of thirty-six years, the patient had noted swelling and pain in the left knee without any known trauma. He had previously been seen at the Graduate Hospital, and fluid aspirated from the knee joint had been purulent in appearance, but no growth had appeared on routine culture. Smear and culture had been negative for gonorrhoea and tuberculosis, as had a guinea-pig inoculation.

Systemic Review: The patient had lost twenty-two pounds in thirteen months. He had slight oedema of the ankle, a cough with blood-tinged sputum, and nocturia.

Physical Examination (July 18, 1942): Temperature and respiration were normal; pulse was 82; and blood pressure was systolic, 100 and diastolic, 58. The skin presented crusted, discrete lesions of the face, neck, arms, and legs. There was a left inguinal adenopathy. The left knee was tender, warm, and swollen. The speech was somewhat slurred, and the pupils reacted sluggishly to light.

Laboratory Studies: Blood examination showed hemoglobin 38 per cent., with the following analysis:

Leukocytes,—8,200,

Polymorphonuclear leukocytes,—	92 per cent.,
Lymphocytes,—	3 per cent.,
Monocytes,—	2 per cent.,
Eosinophiles,—	3 per cent.

The blood serological reaction was negative. Urinalysis was negative as was the gonococcus complement-fixation test. Purulent fluid aspirated from the left knee was negative on routine smear and culture.

Roentgenographic Examination: The roentgenograms showed osteomyelitis of the left patella of uncertain etiology (Fig. 2); also probable healed tuberculosis of the left upper lobe, and an inflammatory process in lower part of right upper lobe, possibly tuberculosis. Diagnoses of tuberculosis and late latent syphilis were made, and intramuscular injections of bismuth were started.

Course: Shortly after admission, the patient began to run a septic type of fever, ranging from 100 to 102 degrees. The pulse ranged from 86 to 130, and respiration was elevated. Two weeks after admission, the right elbow became painful and swollen. Sanguineopurulent material aspirated from the elbow was also negative on routine smear and culture. Blood culture was negative. Three sputum examinations were negative for acid-fast organisms on smear. Treatment consisted of general measures, repeated blood transfusions, and a course of sulfadiazine totalling thirty-four grams in nine days, with a plasma sulfadiazine level of 9.4 milligrams per 100 cubic centimeters of blood. The left prepatellar bursa was incised and drained, and routine cultures were again negative. Despite these measures, the patient's condition remained unimproved. The leukocyte count now hovered between 10,000 and 15,000, and the hemoglobin around 40 to 50 per cent.

On August 7 (three weeks after admission), sulfathiazole 5-per-cent. ointment was applied to the skin lesions, but in five weeks had had no effect. The left metacarpophalangeal joints became involved. Without symptoms, an abscess of the right knee formed and drained spontaneously. Roentgenographic examination showed further destruction of the left patella, and the right elbow joint space was hazy and narrowed; the lower part of the right humerus showed an early destructive process.

One month after admission (August 20), a biopsy was done on a granulomatous skin lesion of the upper lip, which resembled that of bromidism. The pathological diagnosis was blastomycosis which histologically resembled blastomyces dermatitidis. Coincidentally, a repeated blood serological test showed a positive Kolmer, despite the continuation of bismuth intramuscularly.

Rapidly both wrists, the left elbow, and the left great toe became involved, and many soft-tissue abscesses developed on the face, neck, right forearm and wrist, right knee and foot, and left knee (Figs. 3-A, 3-B, and 3-C). Treatment was begun with saturated potassium iodide orally in increasing doses to a maximum of 200 drops three times daily, which was maintained for ten weeks. Local skin abscesses were aspirated, but rapidly refilled. On September 15, the patient was started on a course of irradiation to the skin lesions. This continued until October 7, and consisted of a total of 7,240 roentgen units delivered through seven portals with two-tenths millimeters of nickel filter and a skin-target distance of five centimeters. The Chaoul therapy resulted in some improvement in the local lesions.

Two months after admission (September 16), pus aspirated from the left elbow revealed budding yeast cells. On culture, these were identified as blastomyces hominis. The oral administration of iodide was supplemented with two intravenous injections of 5-per-cent. Lugol's solution (12 cubic centimeters in 250 cubic centimeters of physiological salt solution) with no obvious effect.

Three months after admission (October 14), because of the increasing destruction of the left patella and involvement of the left femur (Fig. 4), with marked general toxicity, a mid-thigh guillotine amputation was performed.

The pathological report included the following: ". . . The knee joint is distended with foul-smelling, brownish pus and partially filled with numerous friable granulations. The soft tissues about the joint surfaces are apparently necrotic, being very friable and covered with these granulations. The articular cartilages show irregular erosions and their edges are not sharply demarcated from the adjacent soft tissues. The underlying bone, however, does not appear to be grossly involved. These changes are noted in the tibia, patella, and femur. The shaft of the femur at the site of amputation and the shaft of the tibia contain no grossly apparent cancellous bone. Their cortices

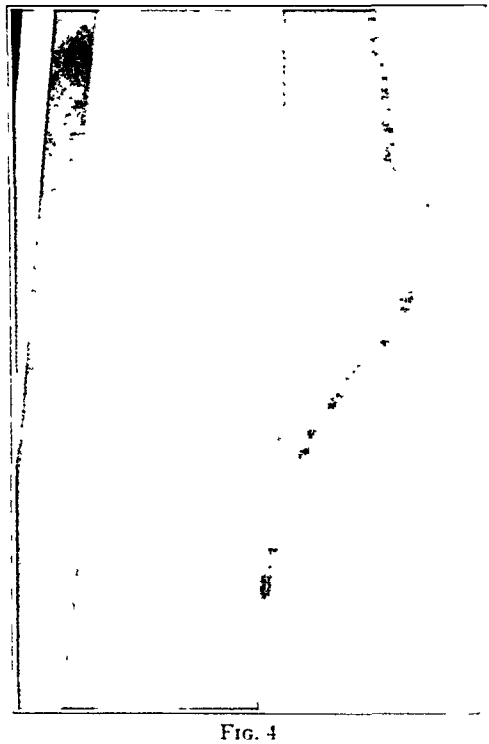

FIG. 4

October 1, 1942. Increased destruction of the left patella, periosteal reaction in the femur and soft-tissue swelling about the left knee joint

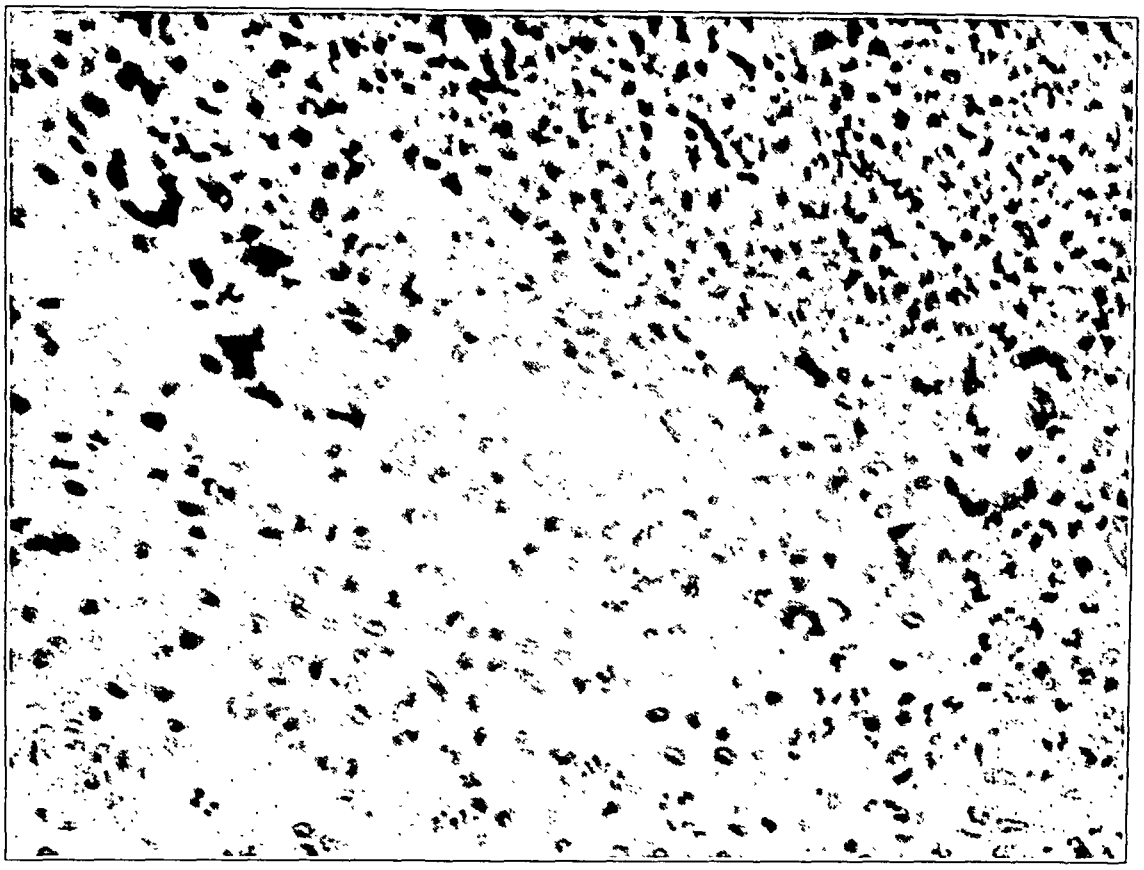

FIG. 5-A

Photomicrograph (× 175) showing multinucleated giant cells suggesting tubercle formation.

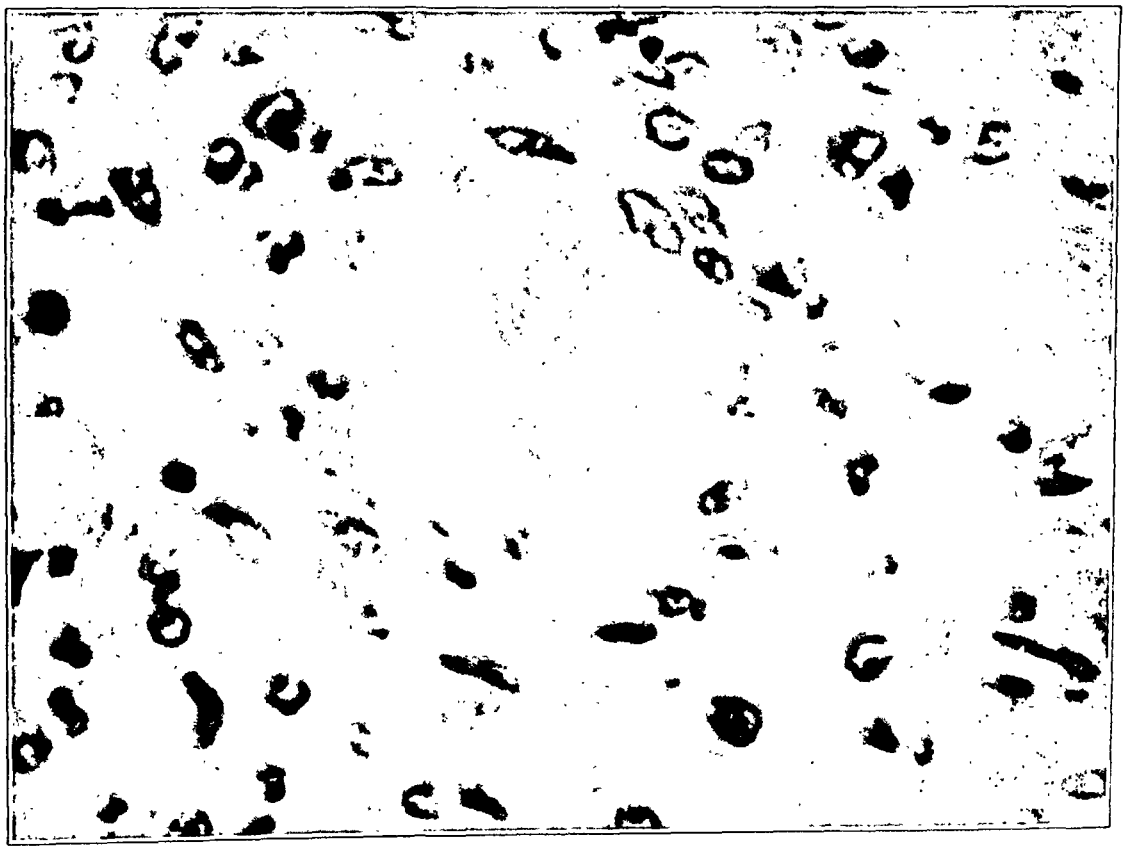

FIG. 5-B

Blastomycetes (double-contoured, refractile body) within a giant cell (× 500).

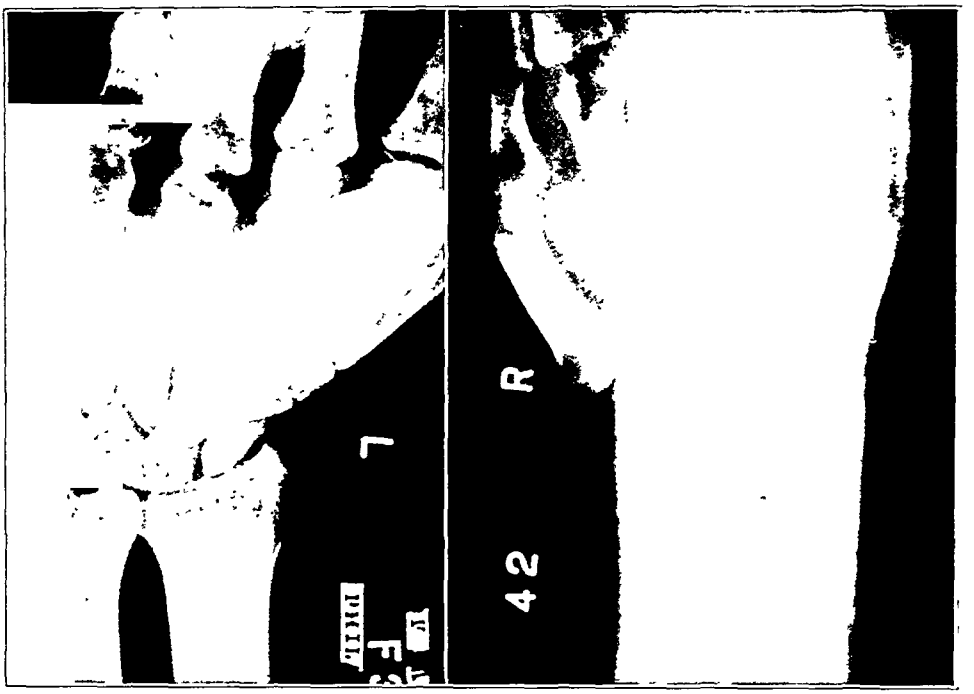

FIG. 6

Roentgenogram taken November 11, 1942, showing bilateral destruction of the carpal bones.

appear thickened, and the marrow cavities are occupied by friable yellow material."

Microscopically the ". . . sections show abundant production of fibrous and relatively avascular granulation tissue, heavily infiltrated by inflammatory cells, among which polymorphonuclear leukocytes and multinucleated giant cells are especially numerous. Much fibrin is also present. Microscopic abscesses are numerous, and occasionally the new fibrous-tissue giant cells are so arranged that they suggest tubercles, however, without caseation [Fig. 5-A]. Scattered throughout, most often within the giant cells, are large numbers of blastomycetes, both preserved and disintegrating [Fig. 5-B]. A few budding forms are destroyed, and there is patchy involvement of the patella. In places, new bone is being laid down on the surface of the bones surrounding the knee. The appearance of the bony involvement suggests that it is secondary to the joint disease. The marrow from the mid-portion of the tibial shaft and that from the femur at the site of amputation show oedema and complete atrophy of the hematopoietic elements, but are without evidence of blastomycosis."

Postoperatively the patient received sulfadiazine for thirty-three days, totalling 188 grams. His fever, which had hovered around 104 degrees, dropped to about 100 degrees. The soft-tissue abscesses were incised and packed with iodoform gauze, resulting in definite improvement. Further roentgenograms showed destruction of the carpal bones bilaterally (Fig. 6).

Four months after admission (November 17), the patient was transferred to another hospital. While there he received further potassium iodide by mouth, irradiation to the skin lesions, and iodocholate ointment locally. However, he became progressively more debilitated, mentally confused, and incontinent, and died on January 22, 1943. Unfortunately no autopsy was performed.

CONCLUSIONS

1. Sixty-seven recorded cases of skeletal blastomycosis are summarized.
2. The mortality rate of this condition appears to be about 89 per cent.
3. An additional fatal case, with involvement of the knees, elbow, humerus, and carpal bones, is reported.

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SURGICAL TREATMENT OF INTERNAL DERANGEMENT OF THE KNEE JOINT AMONG TROOPS IN TRAINING AT FORT JACKSON, SOUTH CAROLINA

An End-Result Study *

BY LIEUTENANT COLONEL MATHER CLEVELAND, MAJOR LEON J. WILLIEN, AND MAJOR PATRICK C. DORAN

Medical Corps, Army of the United States

This analysis of the knee-joint operations performed at the Station Hospital at Fort Jackson during 1942 was undertaken by the Orthopaedic Section in an effort to determine whether or not elective surgery upon the knee joint is worth while from a military standpoint. This subject is particularly important to medical officers responsible for the care of troops undergoing their early training. The activities of calisthenics, long marches, obstacle courses, ranger training, *et cetera*, produce a large number of new injuries to knee joints. Previously damaged knees, which were properly overlooked by the Induction Boards, are reinjured in considerable numbers by the rigors of training. As a result, a fairly large number of soldier patients must be treated, or lost as fighting soldiers. It was not an unusual procedure, prior to our entry into the War, to grant a Certificate of Disability Discharge to soldiers who had internal derangements of the knee due to trauma, without considering surgical treatment. Our entry into the War and War Department Circular Letter No. 270, dated December 27, 1941, which states, ". . . No soldier will be discharged from whom any useful service can be obtained . . ." have revised this procedure somewhat, in that very few patients with intra-articular knee-joint damage are now discharged from the Service. They are subjected to surgical treatment or reclassified to Limited Service † without surgery.

Military surgeons have a variety of opinions as to what should be done about these cases. Some believe that all internal derangements of the knee joint, which have been definitely diagnosed, should have the benefit of surgery, while others feel that these patients should be discharged from the Service, under the impression that the Government can obtain no further useful service from them. Since the main function of the Medical Corps is to preserve the fighting strength of the Armed Forces, elective surgery which will not make a man a fighting soldier should, in all probability, not be done in the Armed Forces. This should be borne in mind by all military surgeons.

Since the number of knee injuries is large, some policy regarding their management and disposition should be adopted. It has been the purpose of this survey to gather all the facts in an attempt to indicate a definite trend, rather than to be guided by impressions alone. The authors have endeavored to answer several pertinent questions regarding these cases, such as:

1. Should any internal derangement of the knee joint be operated upon in the Military Forces? If so, which type responds best to surgery?
2. What is the duty status of these soldiers after discharge from the hospital?
3. Should a soldier with a long history of knee disability, who reinjured his knee soon after induction into the Service, be subjected to surgery or reclassified to Limited Service without surgery?

* Presented as part of an Instructional Course at the Annual Meeting of The American Academy of Orthopaedic Surgeons, Chicago, Illinois, January 23, 1944.

† Since the completion of this study, the status of Limited Service has been eliminated. The authors feel that very few of these twenty-seven soldiers who have been operated upon for internal derangement of the knee joint and have been subsequently placed on Limited Service, will fail to meet the minimum standards for induction as prescribed by the War Department Mobilization Regulations. They may present a problem in reassignment.

4. Is successful rehabilitation proportionately high enough to warrant surgery as a routine procedure in these internal derangements of the knee joint?

5. Are any of these soldiers who are operated upon subsequently discharged from the Service because of disability of the knee joint?

A satisfactory answer to these questions should be provided for the military surgeon.

In military, as in civil practice, the ability of the knee to perform after surgery is of the utmost importance. No more exacting test of a knee can be imagined than that imposed upon the infantry troops who make up a large percentage of the population of this post. Drill, calisthenics, marches, obstacle courses, *et cetera*, test a man's physical perfection and the success of surgical rehabilitation much more severely than does any civilian occupation. If, after operation, a knee will stand these rigors of army life, it is safe to assume that the rehabilitation is complete in the fullest sense of the word.

It is not easy to arrive at any conclusions in military surgery in time of war because of the fact that the population of a military post is constantly shifting, which makes adequate follow-up difficult, if not impossible. When a soldier or an officer is discharged to duty, his Commanding Officer or Medical Officer, or the patient himself, may not feel that the operation is as successful as do the hospital staff. It is for this reason that a simple, but adequate, follow-up seemed necessary in order to determine the success or failure of the operation. It should be agreed that, if a soldier is able to resume all his duties in his organization, the surgery has been successful, and the disability has been satisfactorily treated. To secure data for a follow-up, a form letter was prepared and addressed to the patient's Commanding Officer, asking that the following questions be checked and the letter returned:

a. Has the soldier been able to resume all his duties? Yes —— No ——.

b. If not, has he been reclassified ——, or discharged on Certificate of Disability Discharge —— because of the above disability?

c. Remarks:

This type of follow-up practically eliminates the opinion of the Orthopaedic Section of this Hospital. The success or failure of the surgical treatment of these knees has been decided by the patient, his company officers, and his unit medical officers. Replies to these letters have come from all theaters of operation.

In addition to this letter, the hospital records were checked for any later admission of the patient at which time any reference had been made to the knee in the history or physical findings. The records of the Medical Reclassification Board were also checked, and, to our chagrin, some cases were found which had been referred to the Board the day following discharge from the Hospital, even though we had felt that the result was excellent at discharge. The consultation records of the Out-Patient Orthopaedic Clinic were also checked, in order to exhaust all possible sources of information concerning the subsequent duty status of these soldier patients who had had an arthrotomy of the knee. No attempt has been made to get full statistical data on the range of motion of the knee, the presence or absence of swelling of the knee, or atrophy of the thigh or calf. These are all important and should be noted where examination is possible. The authors have been forced to consider the result satisfactory, if the soldier has been able to do full duty; and unsatisfactory, if he has been reclassified for Limited Service or has been discharged.

The data for this study was based on the seventy-six arthrotomies performed on seventy-five soldiers, during the year 1942, for internal derangement of the knee.

Length of Service

The average length of army service of these seventy-five soldiers was eleven and one-half months. The longest period that any of this group had served was four and one-half years, while the shortest was seven days, which is practically stepping from the induction station into the hospital.

Race

There were seventy-four white soldiers and one negro in this series. The actual proportion of negroes to white troops at this post is one to twenty-five. This, while not at all conclusive, suggests that internal derangements may occur with less frequency among negroes.

Age

The average age of these soldiers was twenty-six years, which is probably the average age of the soldier at this post. The oldest soldier was forty-two years old, and the youngest was twenty.

Arm of Service

These soldiers were distributed among the various branches of the Army as follows:

Infantry	33
Field Artillery	10
Air Corps	7
Engineers	6
Quartermaster	4
Tank Destroyer Battalion	3
Cavalry	3
Ordnance	3
Station Complement	3
Signal Corps	2
Medical Battalion	1
Total	75

By far the largest number were from the combat troops.

Rank or Grade

There were twenty-five commissioned officers, non-commissioned officers, and air cadets, and fifty private soldiers.

Injured in Line of Duty

The question of whether or not these knee injuries were acquired in line of duty is of importance. If a knee joint is injured in line of duty, the Armed Forces have an obligation to use every means at hand to rehabilitate the individual. If, however, the original injury existed prior to induction or enlistment, the question arises whether to perform an operation, treating the patient as if the injury had been incurred in line of duty and thus make the Government responsible for his situation, or to reclassify the soldier for Limited Service without surgery. Forty-one knees were considered to have been injured in line of duty, while the defect in thirty-four knees was considered to have existed prior to induction.

History of Injury

Sixty-three of these seventy-five soldiers and officers gave a history of injury to the knee joint, while among the remaining twelve, no history of trauma could be obtained.

Treatment

In each instance, the treatment consisted of exploratory arthrotomy of the knee joint, and excision of a damaged meniscus, loose body, or damaged articular cartilage, as the case might be. The right knee was involved forty times, and the left knee thirty-five times. The surgery was done principally by the senior members of the Orthopaedic Section, but ten other qualified surgeons, who were either junior members of the Orthopaedic Section or members of attached units, operated under supervision on a certain number of these patients

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Type of Derangement

Internal derangements of the knee found at operation were:

Tear of the medial meniscus	35
Tear of the lateral meniscus	6
Tear of both medial and lateral menisci	3
Cyst of the lateral meniscus	4
Cyst of the medial meniscus	2
Osteochondritis with or without a loose body in the joint or damage to the intra-articular cartilage (meniscus)	13
Fracture into the joint with tear of the medial meniscus	2
Fracture into the knee joint without cartilage injury	1
Gunshot wound of the knee	1
Xanthoma of the knee joint	1
No pathological condition demonstrated at operation	8
Total	76

Accuracy of Diagnosis

The accuracy of diagnosis in 89.5 per cent. of the patients operated upon is evidenced by the fact that in only eight instances was it impossible to demonstrate a definite pathological lesion. Tears of the medial meniscus are the most common intra-articular lesions found in the knee joint; and such injuries were present in over 50 per cent. of the cases.

Length of Hospital Stay

These seventy-five soldiers and officers remained in the Hospital for an average of fifty-eight days after operation; the shortest stay was twenty days, and the longest 223 days. Since these soldiers must be fit for duty on discharge from the Hospital, a post-operative period of eight weeks is not excessive, but is probably inadequate for return to full field duty. A temporary reclassification to Limited Service for three months might have prevented unqualified reclassification to Limited Service in some instances.

Follow-Up

An end result is known in sixty-three, or 84.0 per cent., of the seventy-five patients.

Doing full duty	29 or	46.0 per cent.
Reclassified for Limited Service after operation	27 or	42.9 per cent.
Reclassified for Limited Service prior to operation	3 or	4.8 per cent.
Discharged on Certificate of Disability Discharge, or retired from the Service on account of the knee condition	4 or	6.3 per cent.
Total	63 or	100.0 per cent.

Of the twenty-seven soldiers and officers who have been reclassified for Limited Service following operation, eight were recommended by the authors for this duty status. The remainder were returned to full duty in the belief that they would resume that status and not require reclassification. The authors were wrong on their estimate of the duty status of 70 per cent. of those who were eventually reclassified. These soldiers and officers are the group that we feel would have been helped by a three-month period of reclassification and then a re-examination for full-duty status. The period of eight weeks before return to full duty was too short.

There were four patients (6.3 per cent. of the total group on whom there are follow-up reports) who have been separated from the Service on account of continued complaints about the knee which were thought to be justifiable by Boards of Officers. These cases were:

CASE 1. A soldier, with a history of injury prior to induction, was found at operation to have a long split in the posterior three-quarters of the medial meniscus. The cartilage was entirely removed by means of

TABLE I

END RESULTS IN RELATION TO VARIOUS INTERNAL DERANGEMENTS OF THE KNEE JOINT

Injury	Known End Results	Officers and Soldiers on Full Duty		Officers and Soldiers Reclassified to Limited Service				Officers and Soldiers Separated from Service by Certificate of Disability Discharge or Retirement after Operation	
				Prior to Operation		After Operation			
		No.	Per Cent.	No.	Per Cent.	No.	Per Cent.	No.	Per Cent.
Tear of medial meniscus	29	13	44.8	3	10 3	12	41.4	1	3 5
Tear of lateral meniscus	5	2	40 0	0	0 0	3	60.0	0	0 0
Tear of both medial and lateral menisci	2	0	0 0	0	0 0	2	100 0	0	0 0
Cyst of lateral meniscus	3	2	66 7	0	0 0	1	33 3	0	0 0
Cyst of medial meniscus	1	1	100 0	0	0.0	0	0 0	0	0 0
Osteochondritis, with or without loose body	10	5	50 0	0	0 0	3	30 0	2	20 0
Fracture into the knee joint	3	0	0 0	0	0 0	2	66 7	1	33 3
Gunshot wound of the knee joint	1	0	0 0	0	0 0	1	100 0	0	0.0
Xanthoma of the knee joint	1	1	100 0	0	0 0	0	0 0	0	0 0
No pathological condition demonstrated at operation	8	5	62 5	0	0 0	3	37 5	0	0 0
Total	63	29	46 0	3	4 8	27	42 9	4	6 3

a second capsular incision. He was readmitted to another Station Hospital, and was discharged from the Army with a final diagnosis of complete traumatic rupture of the anterior cruciate and fibulocollateral ligaments of the right knee. This was four months after operation. The authors' records do not show that these conditions were present at the time of his operation.

CASE 2. An air cadet had severe osteochondritis of the knee joint. A low-grade postoperative enfection developed, which resulted in ankylosis of the joint. This patient represents the only serious operative complication in the series of seventy-five patients. He was returned to Limited Service seven months after operation, and was discharged from the Army two months later.

CASE 3. An officer had severe osteochondritis of the knee, with some fifteen loose bodies in the joint. This condition unquestionably existed prior to his entering the Service. Following operation, he steadfastly refused to admit any relief of symptoms, and insisted that the condition followed an injury sustained in the Service. It was finally necessary to retire this officer eleven months after operation.

CASE 4. A soldier, whose injury had occurred in line of duty, was struck by an automobile while marching in formation. He sustained fractures into both knee joints. A torn medial cartilage was removed from the right knee and the soldier was discharged from the Hospital to Limited Service on March 23, 1942. He was discharged from the Army nineteen months after operation, because of limited motion in the operated knee, associated with considerable atrophy of the thigh.

Relation between Type of Internal Derangement and End Results

As has been stated, tears of the medial meniscus are the most frequent type of derangement encountered. In 44.8 per cent. of these cases, the patients have been rehabilitated by surgical treatment, and have remained on full field duty. The study also shows that patients with cysts of the medial and lateral menisci have been rehabilitated to full duty in a high percentage of cases. In 50 per cent. of the cases of osteochondritis, the patients have returned to full duty. (See Table I.)

Relation of Rank to End Result

There is doubtless greater incentive for the officer group to return to full duty, and there may also be more opportunity for the members of this group to take special care, and spare themselves for the few additional weeks that may be necessary for rehabilitation. It is striking that 71.4 per cent. of the officer group and only 33.3 per cent. of the private-soldier group have returned to full field duty. (See Table II.)

TABLE II

RESULTS OF OPERATIVE TREATMENT IN RELATION TO RANK

Group	No.	Reported Follow-Up		Returned to Full Duty		Reclassified to Limited Service		Certificate of Disability Discharge or Retired		Returned to Same Duty (Limited Service)	
		No.	Per Cent.	No.	Per Cent.	No.	Per Cent.	No.	Per Cent.	No.	Per Cent.
Officers, non-commissioned officers, and cadets	25	21	84.0	15	71.4	4	19.1	2	9.5	0	0.0
Private soldiers	50	42	84.0	14	33 3	23	54.8	2	4.8	3	7.1
Totals	75	63	84 0	29	46 0	27	42.9	4	6 3	3	4.8

Relation of Injury Incurred in Line of Duty to End Result

Of the twenty-nine patients who are known to be on full field duty, injury had been incurred in line of duty in fourteen, and had existed prior to induction in fifteen. Of the twenty-seven who have been reclassified, eleven had an injury which had existed prior to induction, while sixteen had received the injury in line of duty. Of the three patients who were on Limited Service at the time of operation, two had been injured in line of duty, and one had been injured prior to induction. Of the four patients who were discharged from the Service on Certificate of Disability on account of their knees, three had an injury which had existed prior to induction, and one had an injury which had been received in line of duty.

This means that in thirty-three, or 52.4 per cent., of the sixty-three patients for whom an end result is known, the injury was incurred in line of duty. Only fifteen, or 45.5 per cent., of those injured in line of duty were rehabilitated sufficiently to return to their former military status. Fourteen, or 46.7 per cent., of those with a history of injury existing prior to induction were restored to full duty.

Whether or not the injury was incurred in line of duty is not an important factor in the patient's rehabilitation.

Relation of Length of Service to End Result

Of these twenty-seven soldiers or officers reclassified for Limited Service, fourteen, or 51.9 per cent., had been in the Army less than six months prior to operation, while of the twenty-nine soldiers and officers known to be on full duty, nine, or 31.0 per cent., had been in the Army less than six months prior to their operation. This seems to indicate that the more seasoned soldiers and officers who have had their basic training are much more apt to be able to return to full field duty after an arthrotomy of the knee joint for an internal derangement.

It is possible that Commanding Officers make more allowance for veterans returning

Relation of Branch of Service to End Result

A higher percentage of soldiers and officers in the infantry with internal derangements of the knee joint are reclassified to Limited Service than in other branches of the Service.

SUMMARY

During the year 1942, there were admitted to the Station Hospital at Fort Jackson, for all causes, 22,186 patients. The seventy-five soldiers and officers with internal derangement of the knee joint which required operative intervention represent an incidence of one in each 295 patients admitted. Only a little under 15 per cent. of the total patients admitted with knee injuries were operated upon. Sprains and contusions of the knee are very frequently encountered. Of the patients at this post admitted to the Hospital with injured knees, approximately one out of seven has been operated upon for internal derangement of the joint.

A large number of patients with internal derangement of the knee joint, existing prior to induction, have been either returned to duty for a further trial or to Limited Service. The authors have always tried to avoid operative work on soldiers or officers who have obviously inadequate personalities; who will, in all probability, never do full combat duty: and who may use the operation as a means of avoiding military service. It frequently taxes the surgeon's ingenuity to determine whether a soldier or officer is a good candidate for elective surgery. There are many reasons for this in time of War, and the surgeon must consider the psychic as well as the somatic manifestations in each instance.

A diagnostic accuracy in 89.5 per cent. of internal derangements of the knee joint is, we believe, creditable. In no instance, has a diagnosis of "loose meniscus" been made. There may be such an entity, but the authors are not satisfied unless there is an actual tear.

The patients are seen regularly at ward rounds, and, if there is a doubt of the diagnosis, they may be presented at the daily staff conference. If the injury is the initial one and responds to conservative treatment, the patient is returned to duty, and only if the symptoms recur, and again necessitate hospitalization, is operation recommended. The authors *have insisted upon some physical signs, regardless of how typical the story sounds.*

These physical signs, one or more of which may be present, are, in order of frequency:

1. Atrophy of the quadriceps muscle.
2. Tenderness at the joint margin over the involved meniscus.
3. Increased intra-articular fluid.
4. A palpable slipping of the joint.
5. Blocking of motion in the joint. This usually occurs at 150 to 160 degrees of extension. It is called locking, but the knee is not actually locked, as there may be 50 to 75 degrees of motion present in the knee.

There was only one serious complication, a low-grade infection which progressed to ankylosis of the joint,—an incidence of 1.33 per cent. There were no deaths.

There is but one point in technique which should be stressed. The operative removal of the meniscus should mean that the entire meniscus is removed. This is made possible by a second, posterior incision in the capsule as described by D. M. Bosworth.[1]

CONCLUSIONS

1. In 1942, seventy-six arthrotomies of the knee joint for all causes were done on seventy-five patients; the end results are known in 84.0 per cent. of the patients.

2. Of these seventy-five patients, 46.0 per cent. of those whose end results are known have been rehabilitated to full-duty status, and 42.9 per cent. have been reclassified for Limited Service following operation.

In tears of the medial meniscus, which is the most frequent internal derangement encountered, 44.8 per cent. of those with known end results have been returned to full duty

following operation. The ability of the knee joint to endure the rigors of full field duty after operation is ample proof of complete rehabilitation.

3. Reclassification to Limited Service depends upon a number of factors, as follows:

a. The emotional stability and personality of the soldier or officer. These should be studied as carefully as the local knee condition. Those candidates who are unstable or generally poor soldier material should be reclassified for Limited Service without surgery.

b. If the patient is an officer, non-commissioned officer, or cadet, he is twice as likely to return to full duty as is a private soldier.

c. All patients with intra-articular fractures, with or without damage to the intra-articular cartilage, and all with injuries involving both menisci, have been reclassified for Limited Service or discharged from the Army.

d. Of those patients with osteochondritis dissecans, with or without injury to the intra-articular cartilage, 50 per cent. have been reclassified for Limited Service.

e. If the length of Army service of the soldier or officer is under six months at the time of operation, he is more apt to be reclassified for Limited Service.

4. It is rare indeed for a patient with an intra-articular derangement of the knee joint to merit a Certificate of Disability Discharge. There have been but four instances in which such a discharge has been granted in this series of seventy-five cases.

5. The question of whether the injury was incurred in line of duty or existed prior to induction has been no factor in determining the end result in this series of seventy-five patients.

1. Bosworth, D. M.: An Operation for Meniscectomy of the Knee. J. Bone and Joint Surg., XIX, 1113, Oct. 1937.

THE SOLITARY BONE CYST *

A Report of a Case of Twenty Years' Duration

BY SAMUEL KLEINBERG, M.D., F.A.C.S., NEW YORK, N. Y.

The author wishes to report the history of, and the roentgenographic changes in, a solitary bone cyst which had existed for somewhat more than twenty years without any mishap and without surgical intervention. Neither in his own experience nor in that of any of his colleagues at the Hospital for Joint Diseases has there been a patient with a similar history who has gone on for so long a period without either a pathological fracture, or symptoms requiring medical attention. The interesting features which prompt the recording of this case are the following: (1) the natural progress of the lesion, uninfluenced by either trauma or an operation; (2) the benign character of this type of cyst, despite the long duration; (3) the continued existence of the cyst, apparently disproving the belief that it may heal spontaneously; (4) the ease with which this type of cystic disease may be completely eradicated; and (5) the exceptionally good fortune which attended this patient, since, because of the location of the cyst, a pathological fracture would have led almost inevitably to a coxa vara deformity, and a functional disturbance in the hip and the limb.

CASE REPORT

C. N., a male, twenty-five years old at present, consulted the author for the first time in 1936 because of a cyst in the neck of the left femur which he knew had been in existence since he was about two years of age. He had limped at various times during childhood. Several physicians were consulted, among them a prominent European surgeon who told the family that the boy had a cancer and that it was incurable. An accurate diagnosis was first established by the late Dr. Reginald Sayre in 1922, when the patient was four and one-half years old. An operation was advised and refused, mainly, the author believes, because the lesion caused no symptoms. In June 1942, the patient returned to the Hospital and requested that he be operated upon. The series of roentgenograms in the author's possession covers a twenty-year period, from 1922 to 1942, and exhibits many interesting features. The series includes roentgenograms taken every few years, but those taken on seven occasions have been selected as adequately illustrating the changes.

1922: The earliest roentgenogram in the series (Fig. 1-A) shows a fairly large cyst in the neck of the left femur. It extends downward from one-half of an inch below the epiphyseal line across the intertrochanteric line to about one and one-quarter inches below the greater trochanter. The cortex is thin, and there are several bone trabeculae within the cystic area.

1925: The cyst is distinctly visible in the roentgenogram, but is considerably altered (Fig. 1-B). The area in the femoral neck appears to be only slightly rarefied. However, the region below the middle of the greater trochanter, extending down into the femoral shaft for two inches, is markedly rarefied, and the cortex is greatly thinned. There is no expansion or perforation of the bone, and no invasion of the epiphyseal plate of the greater trochanter.

1927: Roentgenographic examination shows that the spongiosa in the neck is only slightly rarefied, and that the cortex is approximately normal in thickness (Fig. 1-C). In the absence of the known existence of a cyst, the architecture of the bone in the neck would not attract attention. In the area below the trochanter, the bone is markedly rarefied, and there is some thinning of the cortex. There has been very little change for the worse during the preceding two years.

1938: The femur has lengthened considerably (Fig. 1-D). Rarefaction is again visible at the base of the neck, but it is not prominent. Below the trochanters the rarefaction and loss of bone substance is very marked, and there is considerable cortical erosion or thinning over an area of at least one and one-half inches. It is noteworthy that the bone in the proximal three-fourths of the femoral neck appears normal.

1935: The roentgenogram reveals a large triangular area of marked rarefaction in the femoral neck (Fig. 1-E). The apex of this triangle is one-half of an inch below the epiphyseal line, and its base is at the intertrochanteric line. The triangle appears so clear that all of the spongiosa must be gone; the cortex is distinctly thinned. On the other hand, in the region below the trochanters, where there was extensive rarefaction, the bone tissue is denser. The rarefaction is distinctly less pronounced, and there are many bone trabeculae. The cortex here is about one-half as thick as that of the shaft of the femur.

* Read at the Annual Meeting of The American Orthopaedic Association, Cleveland, Ohio, June 7, 1943.

1938: The triangular area of rarefaction in the neck has increased in size (Fig. 1-F). Below the trochanters the rarefaction is less marked, and the cortex is of nearly normal thickness.

1942: The roentgenogram shows that the triangle of rarefaction in the femoral neck is very clear and very large (Fig. 1-G). It occupies at least four-fifths of the entire area of the neck. The limits of this triangle are clearly defined, and the cortex, especially along the upper border of the neck, is very thin. Below the trochanters there is some rarefaction. There are many bone trabeculae, and the whole area looks quite strong.

The patient was operated upon June 1, 1942. The neck of the femur and the upper part of the shaft were thoroughly exposed. A single cavity was found occupying the distal three-fourths of the neck, and extending for about two inches across the intertrochanteric line into the femoral shaft. The cortical bone in the neck was very thin, but the bone in the shaft segment was fairly thick, with many ridges of varied size and thickness. In the femoral neck, there was a distinct membrane which peeled off the bone. Within this membrane was serosanguineous fluid. Upon removal of the membrane, the inner surface of the bone was discovered to be rough and fairly hard. Little tissue could be scraped from it. The bony wall of the cavity in the femoral neck was thoroughly curetted, the bony ridges in the subtrochanteric area were partly removed, and the whole area was filled with bone grafts taken from one of the tibiae. The wound healed by primary union. A roentgenogram taken in December 1942, six months after the operation, shows obliteration of the the cystic cavity (Fig. 1-H).

The history of the above case demonstrates that a solitary unicameral bone cyst may persist for many years without spontaneous healing. It is somewhat difficult to explain the seeming recession of the rarefaction in the femoral neck between the years 1925 and 1928. It may be that the cortical bone in the neck was still fairly thick, and obscured the absorption of the underlying bone. The diminution of the rarefaction in the upper part of the femoral shaft and the attempt at repair by the formation of thick bone trabeculae may be explained by the likelihood that the patient had sustained an injury, not severe enough to cause a pathological fracture, but adequate to interrupt the process of erosion and to stimulate new-bone formation. He gives, however, no history of any trauma to the hip. In any event, at operation there were found the essential characteristics of this lesion,—namely, a single-cavity cyst, containing fluid, and lined by a pseudomembrane. The cortex in the femoral neck was markedly thinned, so that it was only a matter of good fortune that a pathological fracture had not already occurred, and it was only a matter of time before a fracture was inevitable, particularly in an area as vulnerable as the femoral neck. It may be correctly assumed also that, had a fracture taken place, there would have ensued malalignment, coxa vara, and a permanent locomotor disability.

FIG. 1-A

C. N., 1922. Note the large cyst in the neck of the femur. This extends down across the intertrochanteric line into the femoral shaft.

In considering the matter of

FIG. 1-B

C. N., 1925. The cyst appears to be chiefly below the intertrochanteric line. The neck is but slightly rarefied.

FIG. 1-C

C. N., 1927. The cyst, as in Figure 1-B, is chiefly in the subtrochanteric area. The neck is only slightly rarefied, surely not so much as in 1922.

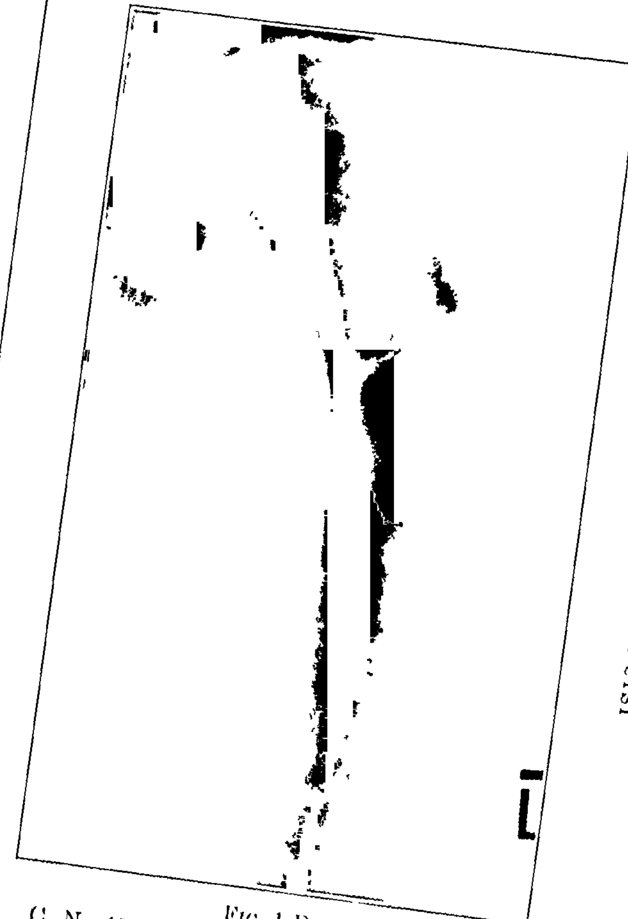

FIG. 1-D

C. N., 1928. The femur has lengthened. The cystic area in the femoral shaft appears multilocular. There is rarefaction at the base of the neck.

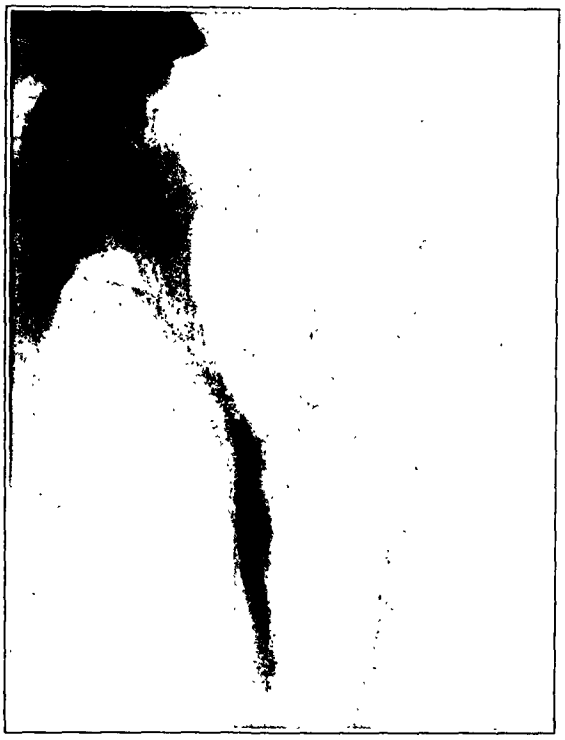

FIG. 1-E

C. N., 1935. There is a large triangular area of rarefaction in the neck; it occupies more than half of the neck, with evident thinning of the cortex. The rarefaction in the femoral shaft is evident, but less distinct than in 1928.

FIG. 1-F

C. N., 1938. The rarefaction in the neck is as marked as in 1935, with perhaps greater thinning of the cortex in the superior border. The rarefaction in the femoral shaft is markedly diminished.

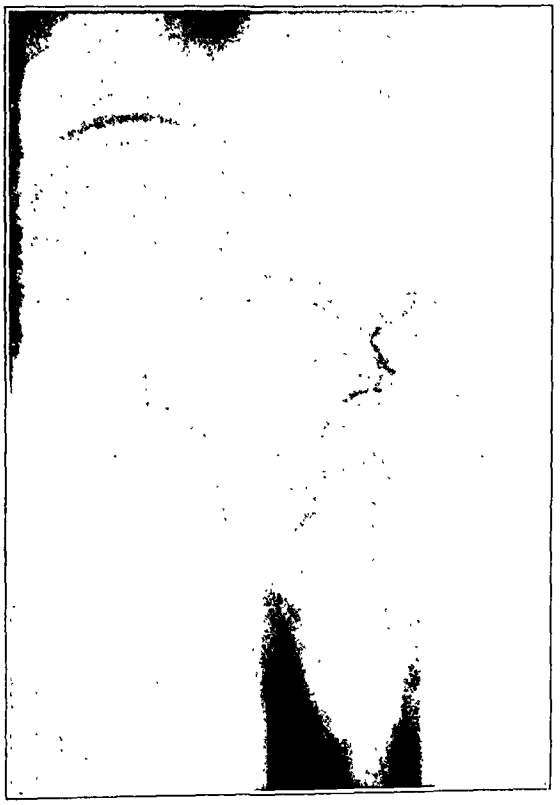

FIG. 1-G

C. N., 1942. The rarefaction in the neck is more extensive, as is also the thinning of the cortex, than in 1938. The rarefaction in the femoral shaft has diminished.

FIG. 1-H

C. N., 1942. Six months after the operation the cyst has been obliterated.

solitary bone cyst, there are two important facts which should be emphasized. The first relates to the effect of a pathological fracture on the healing of the cyst.

When a pathological fracture occurs, healing and obliteration of the cavity *at the site of the fracture* nearly always takes place. However, if the fracture is a simple linear fracture, and all of those which the author has seen or heard about in this type of lesion have been such, the cyst is only partially obliterated. One must, therefore, not assume that,

FIG 2-A

H M, 1935 There is a pathological fracture through the lower part of the cyst of the humerus

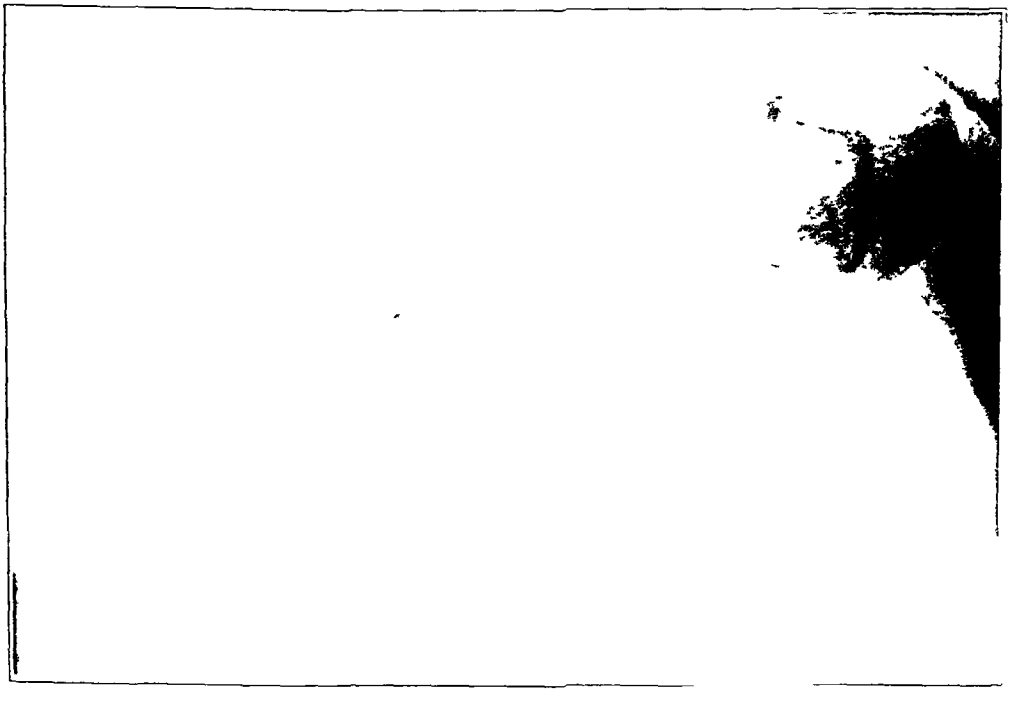

FIG 2-B

H M, 1936 The cyst is healed at the site of the fracture but persists in the rest of its extent

FIG. 2-C

H. M., 1941. The cyst has been operated upon and is now completely healed.

because a fracture has occurred through the cyst, an operation will not be necessary. Conceivably, if the fracture were comminuted and extended *throughout* the cyst, the subsequent healing might obliterate the cavity. The following case illustrates this point.

H. M., a male, fourteen years old, sustained a fracture of the right humerus while playing football. The roentgenogram showed an oblique fracture through the lower pole of a solitary bone cyst (Fig. 2-A). In the course of several months the fracture healed, but the cyst persisted (Fig. 2-B) and was ultimately eradicated by curettage and bone-grafting (Fig. 2-C)

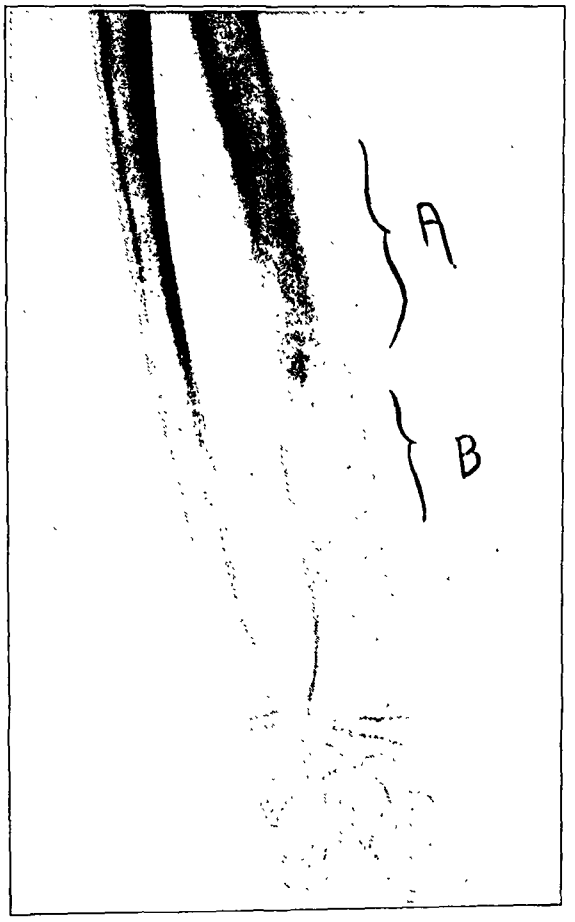

FIG. 3-A

B. F., 1931. There is a cyst in the lower end of the radius. The operation was incomplete. Note that at *A*, where curettage has been done and bone grafts have been placed, there is obliteration of the cavity. However, at *B*, the site not operated upon, the cyst persists.

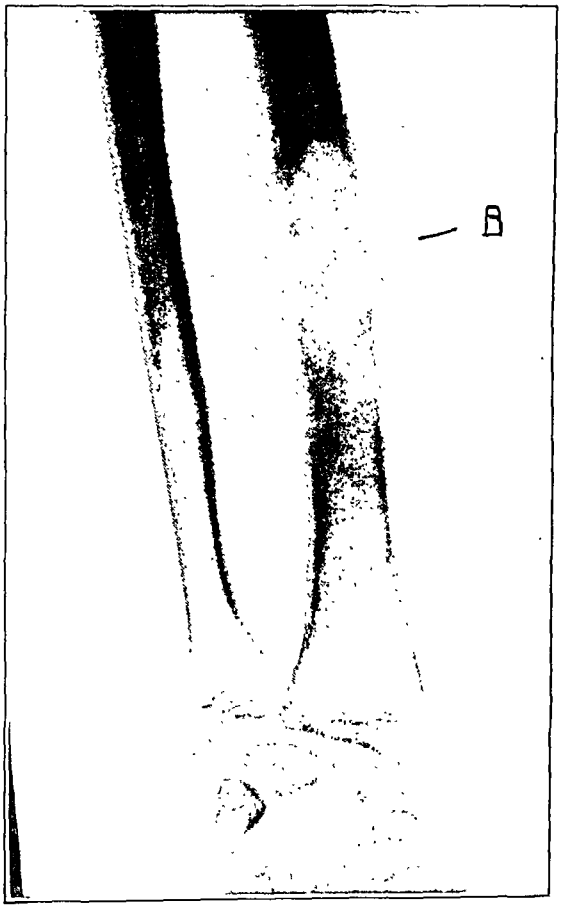

FIG. 3-B

B. F., 1935. Compare with Figure 3-A. The cystic area at *B* is farther from the epiphyseal line because of the natural longitudinal growth of the bone.

The second point of special significance relates to the technique of the complete surgical extirpation of the cyst.

Trauma is an excellent agent, apparently, in arresting the pathological process that is responsible for the formation and perpetuation of the cyst in the bone. However, it is seemingly imperative that its influence be exercised over the entire surface of the cyst. This appears to be true because, in instances in which an operation has been incomplete, the part of the cyst undisturbed by the operation persists.

B. F., a girl, eight years old, had a solitary bone cyst in the lower end of the right radius. The cyst was operated upon, but apparently only the proximal half was curetted and filled with bone chips. Figure 3-A is a roentgenogram of this case showing the grafts in the upper half (*A*) of the cyst, the lower part (*B*) being undisturbed. Evidently, at the time of the operation, the exploration had not been sufficiently thorough. As a consequence, the child continued to have tenderness to pressure over the lower end of the radius. A roentgenogram made four years after the operation shows good healing where the grafts were inserted, but persistence of the portion of the cyst located below the grafted area (Fig. 3-B). Incidentally, this roentgenogram shows the so-called migration of the cyst. The area *B* in Figure 3-B is much farther away from the lower radial epiphysis than it is in Figure 3-A which was made four years previously. This has occurred by reason of the longitudinal growth of the radius in the region between the cyst and the epiphysis.

SUMMARY

From his experience, the author feels that solitary bone cysts may exist for many years, and that they do not heal spontaneously. At varying periods of time, the process of bone erosion may become active, and weaken the bone so that there remains only a thin bony shell subject to fracture from a comparatively mild trauma caused by a direct blow or muscle effort. From this observation, and from the known operative results, it is evident that the treatment of choice is an operation, the essentials of which are the thorough scarification of the bony cyst wall, and the filling of the cavity with bone grafts of cancellous and cortical bone. The operation should be performed as soon as the diagnosis has been established. It should be emphasized that every part of the cavity should be thoroughly curetted, and the cavity should then be completely filled with bone grafts.

DISCUSSION

DR. GEORGE E. BENNETT, BALTIMORE, MARYLAND: I am very much interested in the type of lesion that Dr. Kleinberg has discussed. I have seen a number of such cysts in the neck of the femur, usually making their appearance and producing symptoms in adult life. In one case the pain which attracted attention to the cyst was probably produced by a fracture into the cyst itself.

The operative procedure which has proved most satisfactory has been the removal of a window on the lateral surface of the trochanter, then approaching the cyst, removing the base of the neck of the femur, and saving all particles of normal bone. After a thorough curettement of the cystic cavity, these fragments of bone may be packed into the area. By this procedure one does not have to open the capsule of the joint.

DR. FRANK R. OBER, BOSTON, MASSACHUSETTS: I do not believe that putting bone chips in a bone cyst will make it heal. Dr. Hallock, in his paper at Los Angeles before The American Academy, reported eleven cases in two of which he had used chips, and there was a melting away of the chips. One of my associates had a similar result. Bone will not heal unless it bleeds, and the walls of an old bone cyst are so degenerated that they will not bleed even though they are scarified. If one obtains a little bleeding in a cyst as a result of a fracture, it will heal. If one desires a bone cyst to heal, one must get rid of the membrane lining the cyst and break down the hard cortical bone, especially over the marrow; then one must drill through the cortical bone into the medulla in order to get a hemorrhage from the medullary cavity into the cyst cavity.

The fundamental principle in the healing of bone cysts is to secure hemorrhage in order that any bone structure may be laid down. If there is no hemorrhage there will be no healing in bone cysts or fractures.

DR. JOSEPH E. MILGRAM, BROOKLYN, NEW YORK: In connection with the problem of early operation on bone cyst, may I relate an unusual occurrence in a girl of nine, who had a cyst at the base of the neck of the femur. Fracture through its thin cortex was the cause of its recognition.

Despite immobilization, necrosis of the cyst followed, and non-union of the neck appeared. The segment (one and one-quarter inches) of the neck lying between the intact epiphyseal line of the head and the

cyst was dense white in the roentgenogram, while the head and shaft showed atrophy; the neck had undergone aseptic necrosis. At operation for non-union, after eight months, I removed the cyst, vascularized the necrotic neck by drilling through the epiphyseal line into the head, and let a blood supply in from the shaft, as well, by transfixing with two-threaded Telson steel pins. Rapid healing and disappearance of the epiphyseal line followed. The hip is still normal, seven years after operation.

DR. J. ALBERT KEY, ST. LOUIS, MISSOURI: I would like to have somebody who knows something about it express an opinion as to whether or not one should put a chemical in the bone cyst before packing it with bone chips. Last week I operated on a bone cyst in the upper end of the humerus, and before I got through, I poured alcohol into the area and then wiped it out. The reason for doing so was that a year and a half ago I had one exactly like it and I thought I did a pretty good operation. I filled the cavity with bone chips. The boy was in within the past two or three months, and now the cyst is bigger than when I operated upon it.

These cysts are multilocular, and some of the small isolated cysts may be missed and continue to grow. We do not mind using carbolic acid and alcohol after excision of a giant-cell tumor. If you operate on a good many benign bone cysts, some of them will recur. I would like to know whether one should use alcohol, or something stronger, or no chemical, to prevent recurrence.

DR. ALAN DEF. SMITH, NEW YORK, N. Y.: In the case that Dr. Hallock quoted from our Hospital, and operations we have done since, we have removed completely the membrane lining the cyst and also have removed all the sclerotic bone forming the cyst wall. I favor the use of bone chips, because I think better union is possible.

In answer to Dr. Key's question concerning the sterilization of the cavity, I operated on a bone cyst in the humerus and it recurred. The next time I used zinc chloride and then filled the cavity with bone chips. This time there was no recurrence. Whether the zinc chloride had anything to do with it I do not know, but I think it is a good idea to use a cauterizing agent of that sort.

DR. SAMUEL KLEINBERG, NEW YORK, N. Y. (closing): I have had eight similar cases all in children except one, which was in an adult of forty-two years. I have always been under the impression, and I still think I am right, that the important feature in the operative therapy is to visualize the whole extent of the diseased area carefully and accurately, to remove it thoroughly, and to clean out the entire cavity. Filling the cavity with bone chips is an important aid in the subsequent healing, since the bone chips manifestly promote osteogenesis and obliteration of the cyst cavity. In all of the cases but the adult, the operation consisted of saucerizing the cyst and filling in with bone chips; in the adult I cauterized the cavity wall with 50-per-cent. zinc chloride, and subsequently filled the cavity with bone. I was prompted to use the zinc chloride because other surgeons who had seen this patient previously were quite certain that the lesion was malignant.

I would like to emphasize an error which I committed in the treatment of one of my cases. The patient was a little girl with a lesion in the forearm. I did not recognize the full extent of the cyst and consequently saucerized only part of it. The part untreated continued to grow, and subsequently another operation was considered advisable.

In answer to a question with reference to the case in which I used the zinc chloride, the chemical cauterization did not interfere with the healing.

In summary, the important points in the management of a solitary bone cyst are: first, thorough curettage; second, the filling in of the entire cavity with bone chips; and third, adequate immobilization until the entire cyst area is replaced by new bone. I cannot agree that the cavity should be filled with vaseline gauze and left open. This subjects the patient to the possibility of a secondary infection which can readily be avoided by primary closure of the wound.

OPEN *VERSUS* CLOSED TREATMENT OF ACUTE OSTEOMYELITIS *

A Clinical Report on the Use of Antitoxin and the Sulfonamide Drugs with and without Early Drainage

BY LENOX D. BAKER, M.D., HOWARD J. SCHAUBEL, M.D., AND HAROLD H. KUHN, M.D., DURHAM, NORTH CAROLINA

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It is the purpose of this paper to outline what is thought to be a useful program of therapy for acute hematogenous staphylococcus aureus osteomyelitis, and to report the end results in several groups of osteomyelitic patients who have been treated at Duke Hospital. A knowledge of the problems to be met in the patient with acute osteomyelitis is necessary if the principles of therapy are to be established on a sound rationale.

The prime objective in combatting any infectious disease is the destruction of the invading organism; the secondary objective is the repair of damage done by the disease.

Since the advent of the sulfonamides, sufficient clinical data has been accumulated to prove the worth of sulfathiazole and sulfadiazine in the treatment of staphylococcus infections. Penicillin, another bacteriostatic substance, has been found to be effective in combatting the staphylococcus, but until penicillin or a like substance has become available, sulfathiazole, sulfadiazine, or both are our best bacteriostatic drugs. Hoyt, Davis, and Van Buren have shown that, with the use of sulfathiazole without surgical drainage, the morbidity of acute osteomyelitis can be reduced.

The most important of the secondary objectives in the treatment of a staphylococcus infection is the neutralization of the exotoxins which the organism produces. The staphylococcus produces an exotoxin or exotoxins[7] which have a variety of effects, the four most important of which are: (1) the destruction of leukocytes, (2) the hemolysis of red blood cells, (3) the necrosis of tissue, and (4) the coagulation of plasma.

It is the damage done by these toxins that makes staphylococcus osteomyelitis such a serious disease. These toxins must be neutralized if the patient is to survive. When they are not neutralized, their specific action results in a lowering of the hemoglobin, the appearance of immature white blood cells in the circulating blood, a breakdown of the affected tissues, and a thrombosis of the capillary beds about the area of infection which may discharge infected emboli and cause metastatic lesions. The general effects of the toxins are a hectic fever, elevated pulse rate, nausea and vomiting with a resultant dehydration and acidosis, avitaminosis, and possibly a fatal outcome. It is these effects of the toxins which must be kept in mind when a general plan of therapy is outlined. When the patient has the power to produce his own antitoxin in sufficient amounts, his chances for recovery are excellent. The amount of antitoxin that the patient can produce above that taken to neutralize the toxins can be measured accurately by the titration method. For clinical purposes, the blood picture is a satisfactory guide concerning the degree of toxaemia present.[5] When toxaemia exists, there will be a shift to the left of the Shilling white-blood-cell count in that there is a decrease in the percentage of mature polymorphonuclear cells in relation to the immature juvenile and stab cells present. When the patient's titer, or when the Shilling count, indicates a need for antitoxin, purified Burky's Ha strain of hemolytic staphylococcus aureus antitoxin [3] has been found to be an efficient adjunct in the patient's treatment. The antitoxin is not indicated when a toxaemia cannot be demonstrated, and its need is not based on the presence or absence of

* Read at the Annual Meeting of The American Academy of Orthopaedic Surgeons, Chicago, Illinois, January 25, 1944.

TABLE I

RESULT OF ROUTINE THERAPY PLUS SULFATHIAZOLE, SULFADIAZINE, OR BOTH

Additional Treatment	No. of Cases	Survived	Died	When Last Seen	
				Healed	Draining
Surgical Drainage	30	30	0	9	21
Aspiration	26	25	1*	21	4
Totals	56	55	1	30	25

* A forty-two-year-old, white female was admitted on the seventh day of her illness, with diffused bilateral staphylococcal pneumonia, osteomyelitis of the left femur, and a marked toxaemia. Blood studies showed the hemoglobin to be 93 per cent. (The patient was dehydrated.) The white-blood-cell count was 14,360. The differential white count showed 14 per cent. segmented polymorphonuclear cells, 7 per cent. juvenile cells, and 53 per cent. stab cells which indicated the severity of the toxaemia. The temperature on admission was 40 degrees centigrade (104 degrees Fahrenheit). Roentgenograms showed bone changes in the left femur, which were interpreted as being the result of osteomyelitis. At no time could an abscess be demonstrated. The patient did not receive sulfathiazole until thirty-two hours before she expired; then only eight grams were given over a period of eight hours, after which it was discontinued. Staphylococcus antitoxin was not given until sixteen hours before expiration, when 80,000 units were given in two doses, four hours apart. She died on the eleventh day of her illness. The therapy was inadequate.

a bacteraemia. The antitoxin has no therapeutic value other than its power to neutralize toxin. The routine for administering the antitoxin in the Duke Hospital has been described in previous publications.[1, 2]

Hematogenous osteomyelitis, as often pointed out, is a part of a generalized systemic disease, and it must be so treated. The standing orders at Duke Hospital for patients admitted with a diagnosis of acute osteomyelitis are as follows:

1. A complete examination, including roentgenograms of the parts affected and flat plates of the chest, is to be made, additional roentgenograms to be taken as indicated.

2. Hemoglobin determination, and red-blood-cell and white-blood-cell counts are to be done, the latter to be a differential count to estimate the relative percentage of mature and immature polymorphonuclear cells. The hemoglobin and differential white-blood-cell count are to be repeated daily for the first week, then every other day during the acute stage of the disease.

3. Adequate doses of staphylococcus antitoxin are to be given, if the white count indicates that the patient is not producing sufficient antitoxin to combat the toxaemia.

4. Sulfathiazole or sulfadiazine are to be given, the amount to be determined according to dosage chart. (Until recently the dosage of the sulfonamide drugs was fairly well established, and it was felt that a dose sufficient to maintain a blood level of four to eight milligrams per 100 cubic centimeters was ample. It may be, however, that this level is too low. Robertson has used larger doses of the drugs—four to six grains per pound of body weight per day—without undue signs of toxic effect from the drugs, and, apparently, with earlier control of the disease than is seen with the smaller doses.)

5. Daily urine examinations are to be made for the first week and then every other day as long as the sulfonamides are given. (The first urine examination is made immediately upon admission, as the patient may have had large amounts of a sulfonamide before admission.)

6. Sufficient intravenous fluids are to be given in the form of physiological solution of sodium chloride, with 5 per cent. to 10 per cent. glucose, to combat dehydration and to supply the needed chlorides and carbohydrates.

7. The patient's blood is to be matched for blood transfusion, and transfusions of 150 to 200 cubic centimeters are to be given daily or as indicated.

8. A staphylococcus titer is to be done on admission and following transfusion from each new donor. A staphylococcus titer is also done on all donors.

9. Blood cultures are to be planted on admission and daily thereafter, or until the cultures have been negative on three successive days.

10. Sedative is to be given as indicated to keep the patient comfortable and at rest.

11. Violet-ray therapy is to be given daily after the patient is well enough to be transported to the Physical Therapy Department.

12. The affected part is to be put at rest in the best position for function. Traction, splints, or cast should be used to suit each case.

13. Normal saline compresses are to be applied to the involved area or areas.

14. Abscesses are to be aspirated and cultured. Following aspiration, the abscess is to be gently irrigated with sterile normal saline solution until the washings are clear. One or two grams of microcrystal solution of sulfathiazole is to be instilled with the last washing, and the abscess is then to be re-aspirated as completely as possible. Additional irrigations and local instillation of sulfathiazole are to be done as indicated.

15. The patient is to be put on a high-vitamin diet as early as possible.

16. Accessory vitamins are to be given (intravenously if necessary) as follows (dosage for a child ten years of age or older, smaller dosage for younger patients):

Ascorbic acid, fifty milligrams three times a day.

Thiamine chloride, five milligrams three times a day.

Nicotinic acid, twenty-five milligrams twice a day (preferably the amid form to avoid flushing).

Oleum percomorphum ten drops twice a day (cod-liver oil is preferable if the patient can tolerate it).

It is well established that a patient with an infectious disease may rapidly become deficient in vitamin C and that he requires larger amounts of the vitamin to keep saturated. Also, it has been shown that new capillaries fail to form in fibrin clot in the absence of sufficient vitamin C. These facts make the giving of an ample dose of ascorbic acid so important to osteomyelitic patients. Vitamin A must be supplied if epithelialization is to take place, and vitamin D is necessary for the bone repair. The various B vitamins are essential as stimulators of the appetite and as aids in the patient's general well-being.

During the past three years, fifty-six patients with acute hematogenous staphylococcus aureus osteomyelitis have been treated with sulfathiazole, sulfadiazine, or both at Duke Hospital. In general, all of the patients have been treated by the routine just outlined, the only major variation being in the surgical care. Those treated by incision and drainage, for the most part, have been patients seen before the authors were convinced that incision was not indicated. From a practical viewpoint, the groupings are chronological, but not in the purest sense of the word, as there was some vacillation while the change in the method of therapy was being made. As indicated in Table III, the two groups are comparable from the standpoint of virulence, invasiveness, and resistance. There has been one fatality.

Of the fifty-five patients who survived, thirty had incision and drainage operations, and twenty-six were treated without drainage except for aspiration. When last seen, twenty-one of the thirty patients who had had surgical drainage, had draining sinuses; nine had healed. Of the twenty-six patients treated without surgical drainage, twenty-one had never had a draining sinus. Spontaneous drainage had developed in four. All previous reports on the treatment of staphylococcus osteomyelitis at Duke Hospital have included only those cases with a proved septicaemia. In this report an exception has been made in order to show the results of sulfonamide therapy before admission. Of the fifty-six patients, sixteen had been given a sulfonamide drug before admission. Thirteen of these had negative blood cultures; three had positive blood cultures, of whom one had been given the drug for less than twenty-four hours, and one had been given the drug

TABLE II
SULFONAMIDE BEFORE ADMISSION

	No. of Cases	Blood Cultures	
		Positive	Negative
Given before admission	16	3*	13
Not given before admission	22	16	6
No record before admission	10	6	4
Blood culture not recorded	8†	—	—
Totals	56	25	23

* One had received a sulfonamide for one day, and one, for three days (drugs not known). One had received sulfanilamide for eight days.
† Seven patients were treated by our Service in another hospital.

for three days. The blood cultures in these two patients became negative twenty-four hours after admission. The third patient had been given sulfanilamide for eight days. Forty-eight hours after the drug was changed to sulfathiazole, the blood culture became negative. Twenty-two of the patients had had no sulfonamide therapy before admission; sixteen of the twenty-two had positive blood cultures. No record of drug therapy could be obtained in ten of the patients; six of these had positive blood cultures; four had negative cultures. No blood cultures were recorded on eight of the patients. Seven of these were treated by members of our staff in another hospital where laboratory facilities were not available. Of the thirty patients treated by surgical drainage, thirteen had positive blood cultures; seventeen had negative cultures; nine were given antitoxin; and twenty-one were treated without antitoxin. Of the twenty-six patients treated without surgical drainage, twelve had positive blood cultures; fourteen had negative cultures; seven were given antitoxin; and nineteen were treated without antitoxin.

TABLE III
SEPTICAEMIA AND ANTITOXIN RECORD

Treatment	Blood Cultures		Antitoxin	
	Positive	Negative	Given	Not Given
Surgical Drainage	13	17	9	21
Aspiration	12	14	7	19
Totals	25	31	16	40

CONCLUSIONS

1. A well-planned, useful, supportive routine is necessary for osteomyelitic patients.
2. Staphylococcus toxins can be neutralized *in vivo* by antitoxin prepared from Burky's Ha strain of hemolytic staphylococcus aureus.
3. The mortality rate in hemolytic staphylococcus aureus osteomyelitis can be lowered by the use of sulfathiazole, sulfadiazine, or both.
4. The morbidity of the disease can be reduced if surgical drainage is not used.

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DISCUSSION

Dr. Walter A. Hoyt, Akron, Ohio: The efficacy of any treatment of acute hemorrhagic osteomyelitis is best judged by the end results. The end results previous to the advent of chemotherapy are grim monuments to the inadequacy of our previous treatment.

The recognition of the facts that the disease is a generalized infection, and that the bone lesion is only a localized manifestation of it, has done much to improve methods of treatment. Likewise the trend toward late and conservative surgical handling of the local lesion has definitely lowered mortality, and improved end results. Few would advocate today the return to the teaching of early drainage of the bone.

In June 1941, we (Hoyt, Davis, and Van Buren) presented a consecutive series of cases of acute osteomyelitis treated with sulfathiazole without operation on the local lesion. The method has been continued, and of the twenty-seven cases which have been treated by this method there have been no deaths. Since September 1940, none of our cases have been treated by incision and drainage, either early or late. There have been only four cases which have required rehospitalization. Only two patients have drainage today. Over three years have elapsed on some of these cases. Through correspondence we know of over 100 other cases treated by this method with a very low mortality and with excellent end results.

Dr. Baker has done what we hoped would be done, namely, he has run two series, one treated with incision and drainage, and one treated by the closed method. He reports thirty patients treated with incision and drainage. Of this number twenty-one are still draining, or roughly 66.7 per cent. Of the twenty-six who were treated by the closed method, only four ever drained, or 15 per cent., with no difference in the mortality. The conclusions are obvious, and I congratulate him on his results. Dr. Baker has always been an advocate of treating the disease from the standpoint of a generalized infection, and the low mortality shows the wisdom of attacking the condition from this angle. It is interesting to note that thirteen out of twenty-five patients with negative blood cultures had had sulfonamide therapy before entering the Hospital.

Dr. Baker instills the sulfonamides in the abscess at time of aspiration. I question whether this is necessary. The real indication for aspiration is the relief of pressure and the prevention of spontaneous rupture of the abscess. We have adopted the method of aspiration for the relief of pressure in abscesses over the tibia and more exposed bones, but do not instill the sulfonamides.

We do not advocate rigid immobilization. If voluntary motion is encouraged, there is less bone and soft-tissue atrophy, and less limitation in joint motion.

We have not used staphylococcus antitoxin, but have used the other supportive measures.

In the closed method, a high concentration of the drug can be maintained in the affected area, which is impossible after incision and drainage. By the closed method, we are dealing with one strain of infection, but after operation a mixed infection results. This mixed infection we believe is a great factor in the chronicity and recurrence of the disease. We do not believe that incision and drainage have any effect on lessening the bone involvement. Actually we feel that they may increase it. When sequestra occur, they are usually less massive, and may disappear in the healing process. In two cases, two small sequestra were extruded spontaneously. We have often seen fluctuating purulent abscesses disappear under chemotherapy.

Penicillin has now been used in acute osteomyelitis. We have employed it in four cases, and it has been satisfactory, and appears to act more quickly than the sulfonamides, but here, as with the sulfonamides, we did not use incision and drainage.

The favorable course of the acute phase of the disease with no deaths, the general condition and mental attitude of the patient, together with the end results of the local lesion have been so far superior to our previous experience that we are convinced, now more than ever, that the closed method is the best treatment.

The goal sought in the treatment of acute osteomyelitis is the sterilization of the blood stream and local lesions without operation. The sulfonamides have definitely changed our thinking of the disease and improved our end results, but they are not the complete solution. Penicillin may be the answer. If not, something else will be. Osteomyelitis will not be solved by the surgical approach to the local condition alone.

AMPUTATION FOR CHRONIC OSTEOMYELITIS *

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During the past few years, the conviction has been growing upon the author that many adult patients and surgeons are needlessly waging a hopeless battle to conquer a severe chronic infection in a lower extremity. This struggle is continued month after month and year after year, at the cost of much suffering and prolonged disability on the part of the patient and considerable effort on the part of the surgeon, when an amputation, followed by a properly fitted artificial leg, would eliminate the infection and restore the patient to normal health and an active life in a relatively short time. This opinion was crystallized about a year ago by two cases which will be described below.

It is realized that in writing a paper of this type there is danger that the meaning will be misunderstood, and that some may interpret it as a recommendation that amputation be done in a high percentage of the patients with chronic osteomyelitis. This is by no means the case. Most of these patients can now be cured by surgery and chemotherapy, and can be given useful extremities. However, there is a small percentage of patients in whom the disease is so well entrenched that cure with the preservation of a reasonable amount of function in the extremity is not possible. On the other hand, in most of these patients, the life of the patient is not in any immediate danger from the infection.

Most orthopaedic surgeons have seen adult patients who have one or more foci of chronic infection in bone which have drained continuously over a period of many years, and which has not seriously interfered with the normal activities or noticeably impaired the general health of the patient. In such patients amputation should not be considered, even though it is not possible to cure the disease. On the other hand, there are other patients with chronic bone infection, in whom the infection is more active and has greatly curtailed the activities of the patient over a period of years or even endangered his life, either from an acute exacerbation of the disease or from kidney damage caused by the infection.

In preparing this paper, records of twenty-one patients have been reviewed, for each of whom a major amputation was recommended for the cure of a chronic pyogenic infection in a bone. In each of these patients, the disease was active in one lower extremity. All of the patients were adults. In some, the disease had its onset in childhood as an acute hematogenous osteomyelitis, with resulting persistent chronic osteomyelitis. In others, the disease began in adult life, as an infection following a compound fracture or an operation.

In three instances, the infection involved the foot and ankle. All of these were severe fracture-dislocations at the ankle with severe active pyogenic infection of some months' duration. In each of these an astragalectomy was performed at the request of the patient in an effort to save the limb. In one of these the wound did not heal, and such extensive active infection remained in the foot that amputation was advised and accepted at the second change of plaster, about eight weeks after the operation. In the second case, the wound healed; but infection recurred with resumption of weight-bearing. In the third, the cast is still on; but the author does not believe that a useful foot will be obtained, even if a successful arthrodesis of the tibia and fibula to the os calcis occurs.

There were four instances of severely infected fractures of the tibia and fibula, with

* Read at the Annual Meeting of The American Academy of Orthopaedic Surgeons, Chicago, Illinois, January 25, 1944.

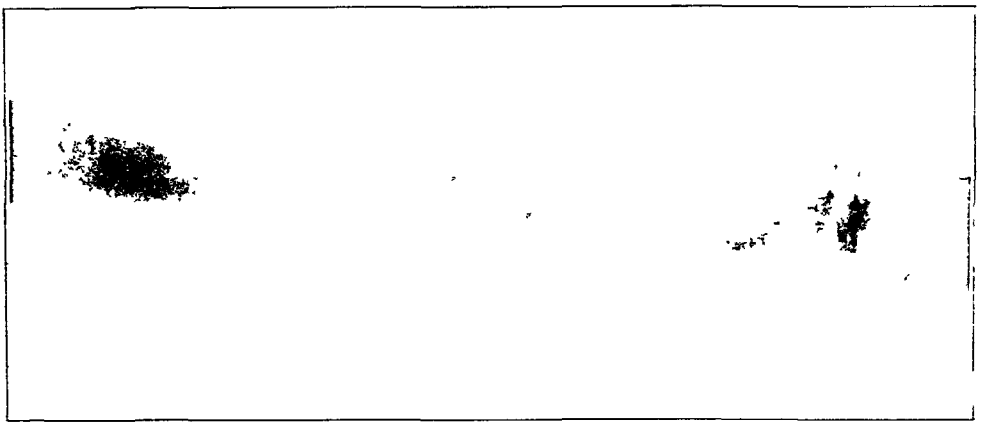

FIG. 1

Showing old osteomyelitis of the femur in a man fifty-four years of age. The onset had been in childhood. An amputation was performed, and the patient returned to active work within a few months.

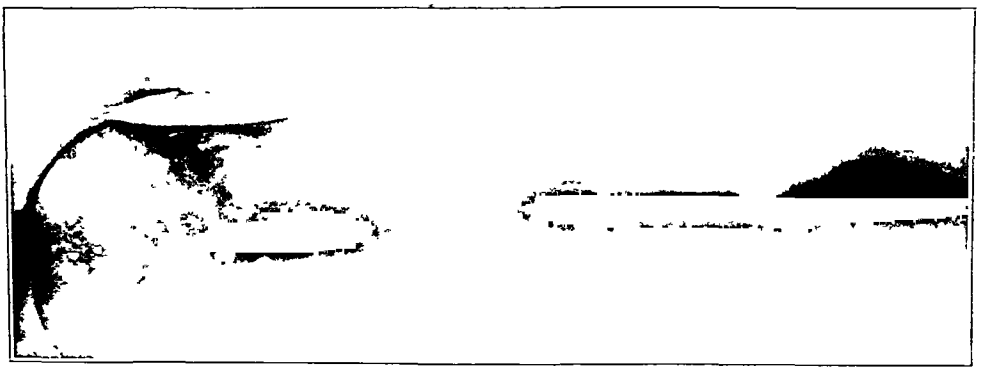

FIG. 2

Showing old osteomyelitis of the femur one year after an attempt had been made to cure by saucerization. The treatment was not successful, and the patient suffered a pathological fracture. The thigh was later amputated.

non-union and extensive necrosis of the ends of the fragments. Amputation was advised because there seemed little chance of securing a useful extremity, even if the infection could have been eliminated by extensive resection of the necrotic bone and eventual bridging of the defect by a successful bone graft. In one patient, the muscles, artery, and nerve in the anterior compartment of the leg were found to be necrotic when the first operation was undertaken for the elimination of the infection. This had been a simple comminuted fracture which had been treated in a walking cast; the proximal fragment had eroded the skin and an extensive low-grade infection had followed. In another, the ankle and tarsal bones were extensively infected. In the other two, the non-union and infection had persisted after three operations on each, and the foot and ankle were markedly fibrosed and in equinovarus.

There were three cases of fracture of the femur with non-union and infection. Two of these were pathological fractures which had followed saucerization operations for chronic osteomyelitis, and in which the weakened bone had failed to thicken or regenerate after the operation. In each, the infection had remained active and the fractures had occurred from slight violence. The other was in a young woman who had rather extreme loss of substance and extensive atrophy of the ends of both fragments following an infected compound fracture of the femur. In spite of several operations, non-union of the femur and extensive infection in the thigh were present.

Three cases were infected compound fractures in which union had been obtained, but the infection had persisted. In one, the ankle and foot were stiff and there was extensive loss of soft tissue in the lower half of the leg; the chronic infection of the bone had caused repeated skin and flap grafts to fail. The second was in an extensively comminuted double fracture of the tibia and fibula with insufficient union to bear the patient's weight. There were several areas of ulceration along the front of the leg and extensive infection in the tibia. In addition there was an equinovarus deformity of the fibrosed foot, and the knee presented a flexion contracture of about 45 degrees. The patient was an old lady who had spent over two years in the hospital trying to get well. When the author suggested amputation, she said that she had been wanting someone to tell her that for a long time.

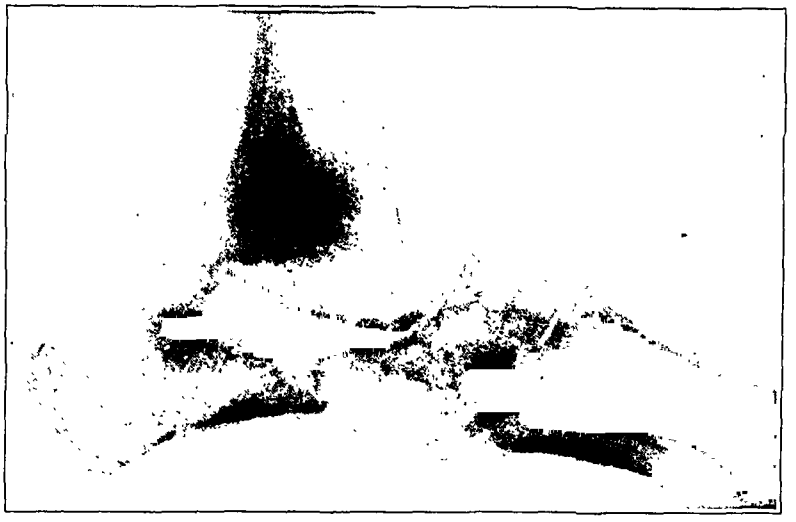

FIG. 3

Showing old compound infected fracture of the ankle. The infection was not relieved by astragalectomy, and amputation was performed about eight weeks after the astragalectomy.

The third patient of this group had ankylosis of the knee, with an extensive low-grade infection in the condyles of the femur, which had not remained healed after three operations, and was constantly painful on weight-bearing.

One patient had been operated upon and a giant-cell tumor had been removed from the inner condyle of the femur and the cavity had been filled with bone chips. The wound became infected, and the patient had had a large amount of roentgenotherapy over a period of three years. The tumor appeared to be arrested, but the infection in the bone persisted, and the knee was stiff. The tissues had been so damaged by the roentgen ray and the infection that there was little chance of obtaining a useful extremity, even if the infection could be eliminated.

The other cases were hematogenous osteomyelitis, which had begun in early life and in which chronic infection of the bone had persisted. Two patients were young women who had been subjected to resection of the diaphysis of the tibia and in whom regeneration had not occurred. The other five cases were old chronic infections of the femur, with marked enlargement and eburnation of the bone and active persistent infection in the bone, which had continued to drain and to cause pain and disability over a period of years, in spite of repeated operations. Two patients had bony ankylosis at the knee, and the others had a variable amount of stiffness in this joint. All were chronic invalids. Two of this last group deserve special mention, because they are the cases which focused the author's attention on amputation as the treatment of choice in some of these patients with chronic osteomyelitis.

CASE 1. A man, forty-four years of age, was admitted to the Barnes Hospital on July 28, 1941. At the age of seventeen years, he had had osteomyelitis of the right femur, which had drained for several months and then had healed after a bone-scraping operation. This had remained healed for nineteen years, and then an abscess had formed, and the thigh had drained constantly during the past six years, in spite of several operations elsewhere.

On admission, there was marked swelling of the entire right lower extremity and thick yellow pus was draining from sinuses on the lateral and posterior aspects of the thigh. There was pitting oedema of the left lower extremity. The roentgenograms showed a dense spindle-like enlargement of the middle third of the right femur with roughening of the surface of the bone and some areas of decreased density.

Laboratory examinations showed the following:

Red blood cells, 5,000.000: white blood cells, 11,900; hemoglobin, 16 grams per 100 cubic centimeters of blood; blood proteins, 5.8 grams per 100 cubic centimeters of blood (albumin, 2 grams; and globulin, 3.8 grams); and non-protein nitrogen, 22 and 36 milligrams per 100 cubic centimeters.

The Congo-red test was within normal limits.

Urinalysis showed: Specific gravity, 1.024; albumin, 4+; occasional red blood cells and white blood cells; no casts or Bence-Jones protein; and urea clearance, 73 per cent. of average normal.

Because this patient had been an invalid for six years and it did not seem possible to cure the infection in the bone, and because of the kidney damage, amputation was advised. This was refused on sentimental grounds; so he was given sulfathiazole by mouth, and the leg was elevated. At the end of twelve days he developed a drug fever which subsided promptly when the drug was discontinued. He left the Hospital on August 22, 1941, somewhat improved.

On October 8, 1942, he again entered the Hospital with pain and swelling of the right lower extremity. The laboratory data were as follows:

Red blood cells, 3,800.000; white blood cells, 20,000; and hemoglobin, 13 grams per 100 cubic centimeters of blood.

The Congo-red test was inconclusive for amyloid disease.

Urinalysis showed: albumin 4+: occasional red blood cells and white blood cells; and many granular and hyaline casts. Phenolsulfonphthalein tests, 10 per cent. excretion in fifteen minutes, 25 per cent. in thirty minutes, and 40 per cent. in sixty minutes.

He again refused amputation, and the swelling again subsided when the leg was elevated and treated with hot wet packs. He was also given sulfadiazine for several days. He insisted on going home on October 22, 1942.

On May 19, 1943, he was admitted with generalized oedema, headache, and vomiting. The specific gravity of the urine was 1.004: the non-protein nitrogen was 67 milligrams per 100 cubic centimeters of blood. The phenolsulfonphthalein test showed less than 5 per cent. excretion in one hour and less than 10 per cent. in two hours. Coma and complete anuria developed and he died on May 31, 1943, apparently of uraemia. Autopsy was refused.

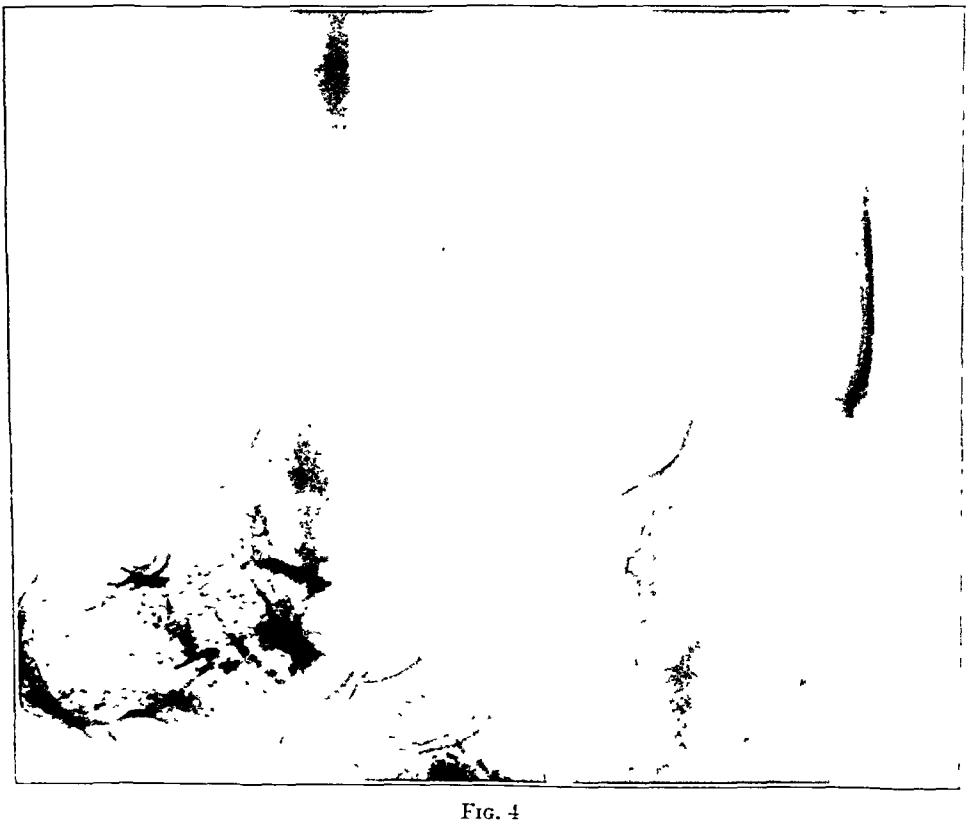

FIG. 4

Showing old compound infected fracture of the leg. Amputation was performed because it was impossible to cover the infected bone with healthy tissue.

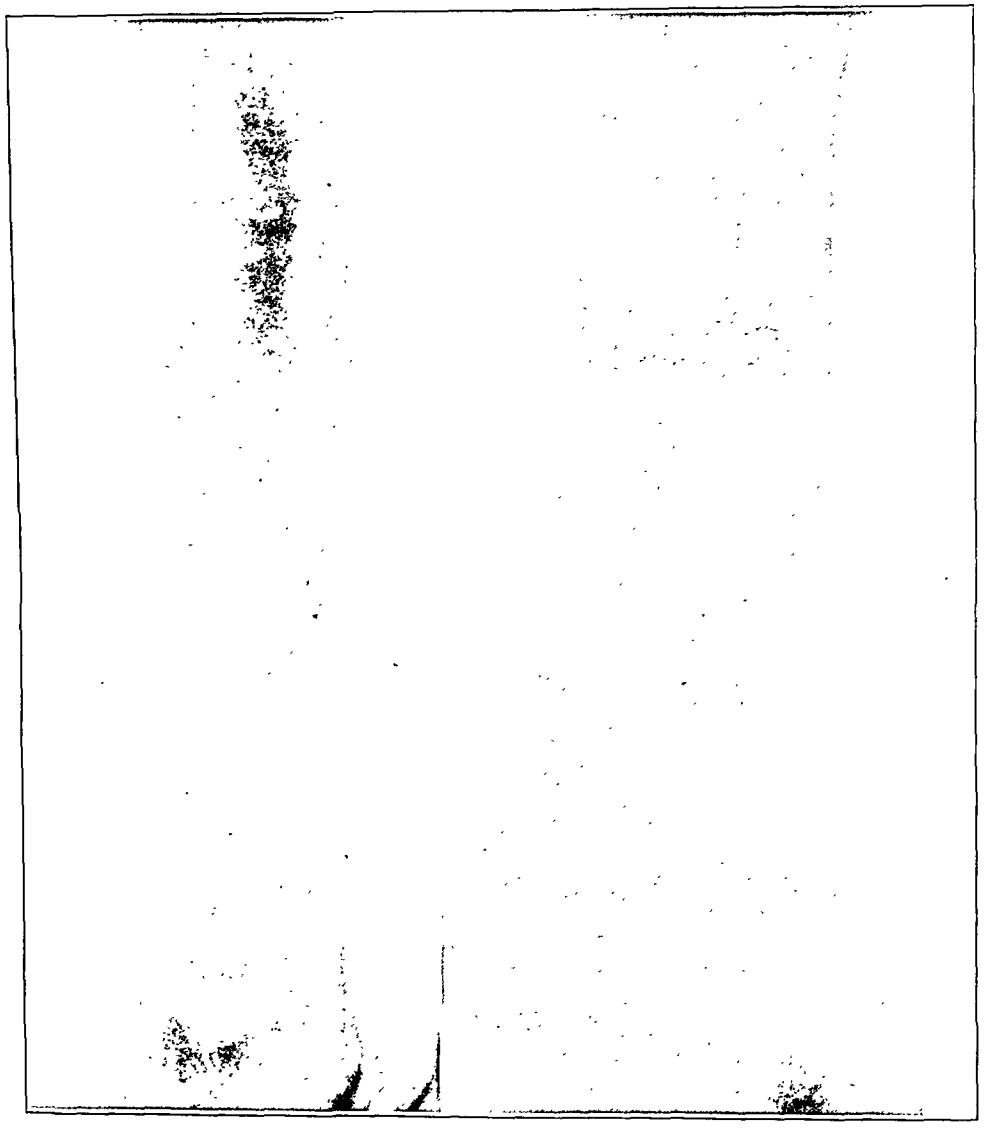

FIG. 5

Case 1. Showing old severe osteomyelitis of the femur with disability of about eight years. Amputation was refused, and the patient died of uraemia two years later.

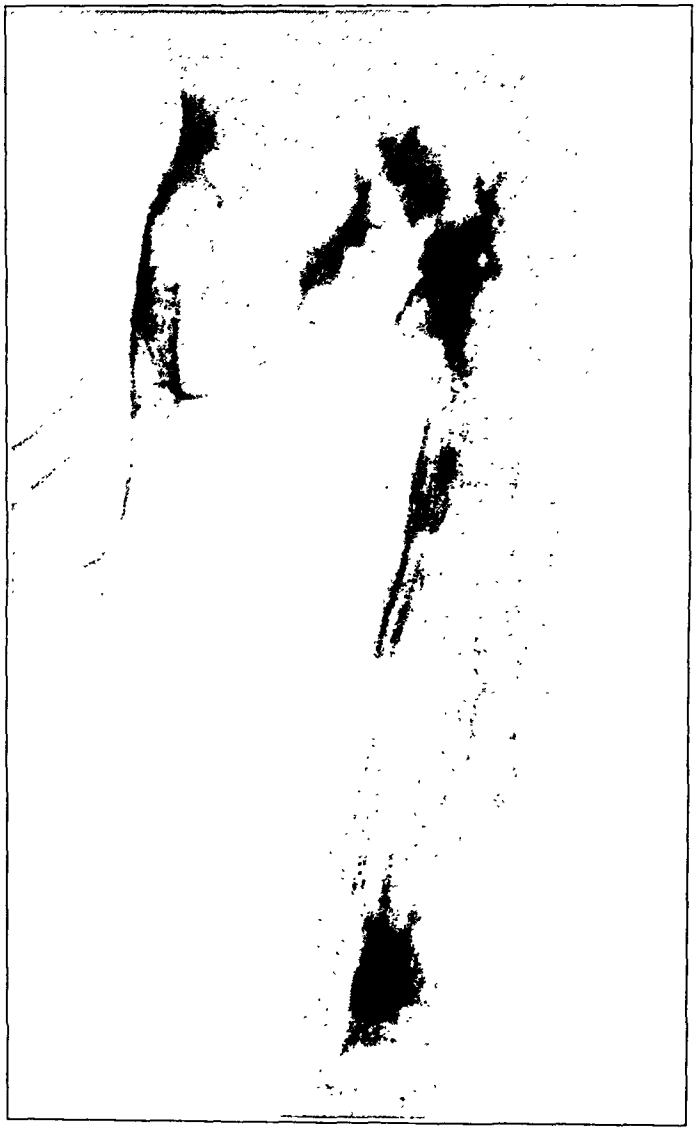

FIG. 6

Case 2. Showing old osteomyelitis of the femur with severe kidney damage. Improvement followed disarticulation at the hip, but death occurred nine months later from amyloid disease.

CASE 2. A man, twenty-six years old, entered the Barnes Hospital on March 22, 1943, complaining of persistent pain in the left thigh which had been present for several days.

Past History. An acute pyogenic infection of the left femur at the age of twelve years had been incised and drained. Since then he had been in the Hospital twenty-three times for incision and drainage of abscesses in various bones, but principally in the left thigh and hip, which had been drained four times during the past year. On January 13, 1940, the urine had showed 2+ albumin; this was the first pathological finding in the urine. On April 1, 1941, the urine had showed 3+ albumin. On May 11, 1942, there had been generalized oedema with headache and vomiting, and the urine had showed 4+ albumin with hyaline and granular casts and occasional red-blood cells and white-blood cells. The specific gravity was 1.001. Other laboratory examinations showed: urea clearance, 24 per cent. of normal average; phenolsulfonphthalein, 7 per cent. in fifteen minutes, 5 per cent. in thirty minutes, and 7 per cent. in sixty minutes. Red blood cells, 5,000,000; white blood cells, 26,000; blood proteins, 5.1 grams per 100 cubic centimeters of blood (albumin, 2.4 grams; globulin, 2.7 grams); non-protein nitrogen, 36 milligrams per 100 cubic centimeters, and blood chlorides, 600 milligrams per 100 cubic centimeters.

On physical examination, there was generalized oedema and tenderness over the middle third of the left femur on the medial side. The left hip was subluxated and ankylosed to the ilium. The laboratory findings were practically the same as those previously reported, and the Congo-red test showed 30 per cent. of the dye retained in the tissues in one hour, which was highly suggestive of amyloid disease.

At the patient's request, the left lower extremity was disarticulated at the hip. He stood the operation better than was expected; the generalized oedema subsided, and his general condition improved rapidly. The wound healed by primary intention, and he left the Hospital on crutches on May 7, 1943.

During the summer and fall he appeared to be in good general health, and worked in a defense plant. He returned to the Hospital in the latter part of December with vomiting and generalized oedema, and died of uraemia on December 31, 1943. The autopsy showed extensive amyloid disease.

Each of these patients died as a result of kidney damage which the author believes was caused by the long-continued pyogenic infection. In the second case, this developed while the patient was under the author's care and the patient himself had to suggest the amputation. Had he suggested it three years earlier he might now be living and well.

It is for this reason that the author wishes to call your attention to amputation as the treatment of choice in certain cases of chronic osteomyelitis. The amputation should be done before the kidneys are too badly damaged, because this form of kidney disease does not appear to be reversible.

What are the criteria for advising amputation in chronic osteomyelitis? In the author's experience, the patients have all been adults. The bones of adults have much less power of regeneration than have those of children after extensive saucerization. In adults, these operations may not cure the disease, because the eburnated bone which is left continues to harbor the infection. In children this eburnated bone may be absorbed and replaced by more normal bone and the infection may disappear. Eburnated bone is apt to be fractured by slight violence and may not heal, as was the case in two of these patients.

The disease in the bone must be so extensive that it cannot be cured by surgery and chemotherapy. None of these patients were treated with penicillin, but the author's present knowledge of this agent leads him to believe that its use would have made little difference in the final outcome in any of them.

In cases where cure of the disease by wide resection is possible, the condition of the extremity must be such that, after the disease has been eradicated by surgery, the function of the extremity will be so impaired that an artificial limb would be preferable. This almost limits the operation to the lower extremity.

The disease must be of such a nature that it causes considerable disability or there should be some evidence that it is impairing the general health of the patient. In patients with kidney damage, the amputation should not be delayed too long.

It is advantageous to perform the amputation while the infection is relatively quiescent. The administration of sulfathiazole by mouth before and after operation permits primary closure of the wound. This was done in seventeen of these patients, and all wounds healed by primary intention.

(*See* DISCUSSION *of this paper, page 362.*)

AMPUTATION OF THE LOWER LEG WITH INDUCED SYNOSTOSIS OF THE DISTAL ENDS OF THE TIBIA AND FIBULA *

BY C. GLENN BARBER, M.D., CLEVELAND, OHIO

From the Department of Surgery, Orthopaedic Service, Western Reserve University and University Hospitals, Cleveland

Bony union of the severed ends of the tibia and fibula, whether spontaneous (Figs. 1-A, 1-B, 3, and 4) or intentionally induced (Figs. 5-B, 6-D, 7, and 8-B), affords the most satisfactory stump in amputations through those bones. When such fusion has been obtained, a firmer stump follows, permitting the fitting of an artificial limb with less pain and discomfort. Hence, the osteophyte, which is a distinct detriment in a femoral stump, may become of material service in amputations of the leg below the knee (Figs. 1-A and 1-B).[1]

The surgical problem of a limb amputation ideally ends with the healing of the operative wound. However, even when this fortunate event takes place, surgical interference all too frequently is again needed. Reamputations on stumps below the knee comprise by far the greatest number of all reported cases.[6,10]

It is not the purpose of this communication to reiterate or discuss the current proposals and opinions pertaining to the success or failure of adaptation of amputation stumps, but rather to present a simple procedure which has been found useful in amputations through the tibia and fibula.

In every amputation, there is impairment of local function. In amputations through the lower extremity, all the bones remaining show alteration of the principal function,—namely, the storing of minerals. Such alteration is manifest in the perviousness to the roentgen ray (Figs. 2-A and 2-B) [8], as well as in the weights of the bones [2] when compared with those of the unamputated side. The loss in weight averages 13 per cent. for both the patella and the femur.[8] The extent of the mineral loss is dependent on two known circumstances,—namely, the height or level at which the amputation was performed, and the extent to which other local functions have been restored.[8] In amputations through the tibia and fibula, in which the distal ends of these bones have become united—either spontaneously or surgically—the remnants show a thickening of the cortex with an accompanying increase in density, which is most obvious at and adjacent to the site of fusion (Figs. 1-A and 1-B). Synostosis of the tibia with the fibula would seem to afford some protection from compression of sensitive interposed structures and permit a greater usefulness.

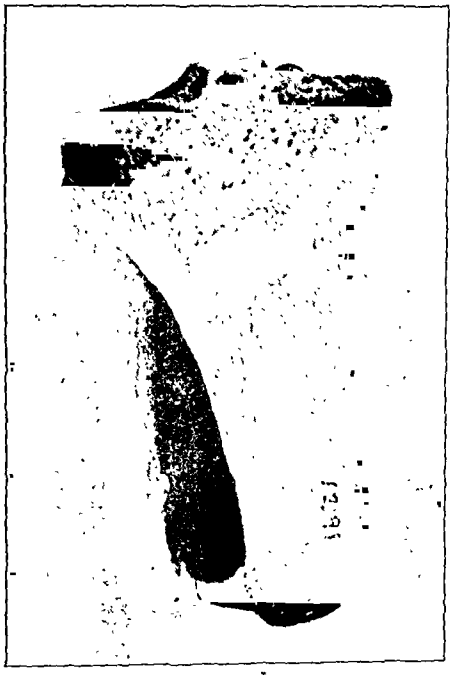

FIG. 1-A

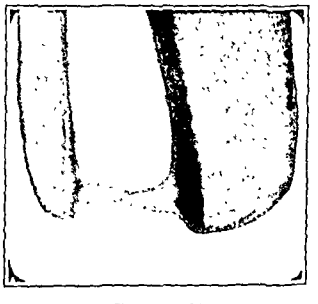

FIG. 1-B

Amputation through the upper third of the right tibia and fibula. (*Reproduced by permission from Annals of Surgery, XC, 991, 1929.*)

Fig. 1-A: Osteophyte uniting free ends of bones.

Fig. 1-B: Roentgenogram showing the thickened and condensed cortex at, and extending upward from, the osteophyte in each bone.

The author was convinced through previous experience that tender amputation neuromata or end bulbs, conical or sharply-pointed bone remnants, circulatory disturbance of sympathetic

* Read at the Annual Meeting of The American Academy of Orthopaedic Surgeons, Chicago, Illinois, January 25, 1944.

FIG. 2-A

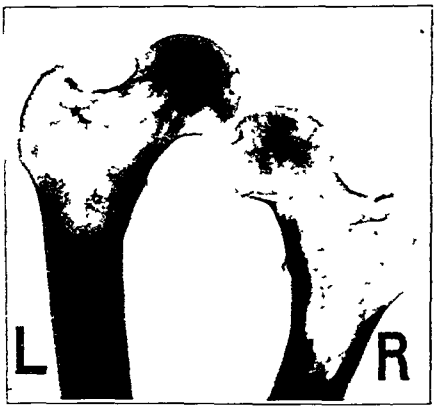

FIG. 2-B

Amputation of the right leg. (*Reproduced from The Journal of Bone and Joint Surgery, XVI, 57, January 1934.*[5])
Fig 2-A: Roentgenogram of both innominate bones.
Fig. 2-B: Roentgenogram of upper femora shows the uniform rarefaction in the right femur in contrast to the patchiness in the innominate bone.

reflex origin[7], and other conditions commonly assigned were singly not the principal cause for bothersome amputation stumps of the lower leg. It, therefore, seemed quite logical, from observing a few excellent stumps in which synostosis of the distal ends of the tibia and fibula had taken place spontaneously (Fig. 3), that the protection and stability thus afforded might be the answer. Others have observed that, when a spontaneous cross union between these bones has occurred, excellently functioning stumps have resulted (Fig. 4).[3] It was, therefore, decided to determine what intentional fusion might accomplish.

OPERATIVE TECHNIQUE

The simplicity of the procedure scarcely justifies its presentation; however, its pos-

FIG 3

Roentgenogram showing synostosis of the tibia and fibula which occurred spontaneously and resulted in an excellently functioning stump

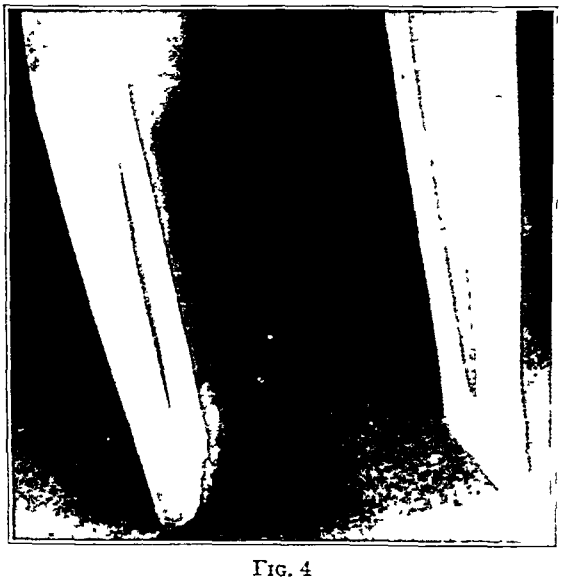

FIG. 4

Cross union between the tibia and fibula resulted in an excellent stump. (*Reproduced by permission from The Journal of the American Medical Association CXIII 997, 1939.*[3])

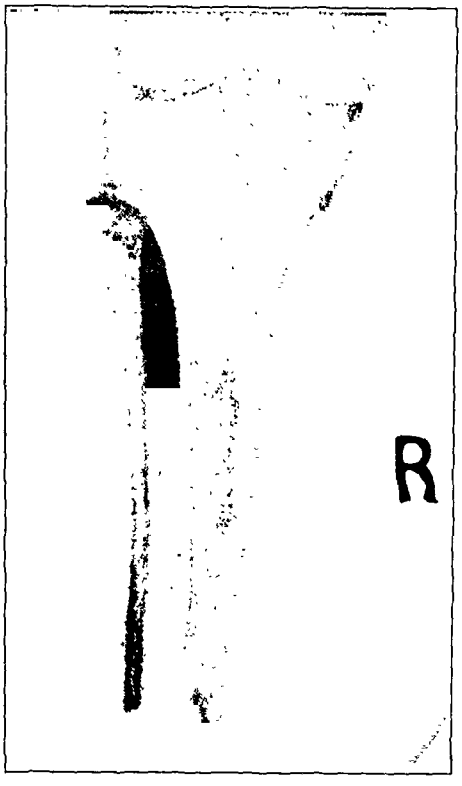

FIG. 5-A

FIG. 5-B

Fig. 5-A: Case 1. G. H. Roentgenogram shows tibial and fibular remnants before induced fusion.

Fig. 5-B: After induced fusion; the pointed distal portion of the tibia was purposely not removed.

sible benefits do. It is applicable in many old bothersome stumps, or may be instituted at the time of primary amputation. In old amputations, the distal end of the fibula is partially cut through from the lateral side and the part of the bone distal to the cut is bent medially, so that it makes contact with the adjacent lateral cortex of the tibia (Fig. 8-B). Suturing the soft structures beneath the fragment of bone is all that is necessary to hold it in position until bony union occurs. When instituted during a primary amputation, a piece of bone, just long enough to make good contact when interposed, may be taken from the fibula and secured between it and the tibia just proximal to their cut ends (Figs. 6-A and 7).

In adults, or when growth of the extremity has become permanently arrested, the tibia and fibula may be severed at or near the same level (Fig. 7). In children, particularly when very young and when the development of the knee joint is quite immature, the fibula should be cut at a higher level than the tibia, and the interposed fragment of bone should be secured at an appropriate angle between the tibial and fibular remnants. Unless this is done, a disparity in the length of the two bones will, in some instances, eventually occur, since the increment in growth from the upper fibular epiphysis is greater than that of the upper tibial epiphysis (Fig. 6-B). When development of the knee joint is nearly complete, epiphyseal arrest of the fibula as well as of the tibia may be justifiable.[3,8]

ILLUSTRATIVE CASES

CASE 1. G. H., a white girl, aged thirteen years when first seen in June 1928, had been unable to wear an artificial limb with which she had been provided, because of pain and ulceration of her stump. Her right leg had been amputated at the junction of the middle and lower thirds, following a crushing injury to her foot and ankle when she was six years old (Fig. 5-A). Her stump was extremely sensitive to compression of the tibial and fibular remnants; and the sensitiveness increased markedly from the proximal to the distal ends of the bones.

On June 29, 1928, the distal end of the fibula was removed and a portion of it was placed between that bone and the tibia (Fig. 5-B). The pointed end of the tibia, the ulcer, and a neuroma, about one centi-

FIG. 6-A FIG. 6-B FIG. 6-C

Case 2. G. B. had an amputation of the lower third of the left leg. (These negatives were reversed in the preparation of the illustrations.)

Fig. 6-A: Roentgenogram taken twenty-one days following the first induced fusion.

Fig. 6-B: Roentgenogram taken two years and one month later, showing excessive fibular growth and the bone insert tapering to a point. The bone insert has united firmly with the tibia, but not with the fibula.

Fig. 6-C: Roentgenogram made two months after the second induced fusion. The bone fragment is firmly united to the fibula, but not to the tibia.

Fig. 6-D: Roentgenogram made one year and nine months after the second induced fusion. The stump is nicely rounded and well covered with soft tissue. The distal ends of the tibial and fibular remnants are favorably separated and solidly bridged by bone. The fibular head on the side of the amputation is at a somewhat higher level than that of the sound side.

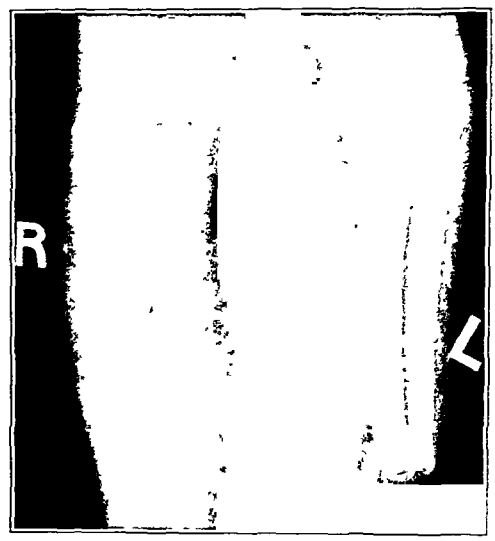

FIG. 6-D

meter in diameter, which was present on the external popliteal nerve, were purposely not removed.

On October 13, her stump was entirely healed, and she had been wearing her artificial limb for more than a month with but very little discomfort. She was observed at regular intervals for several years, and, when last seen, was wearing her prosthesis without complaint.

Although the distal end of the tibia tapered to a point and extended farther than desirable beyond the fibula (Fig. 5-B), her stump was unusually tolerable to pressure and weight-bearing.

CASE 2. G. B., a white girl, at the age of two years had had her left foot run over by a street car. Her leg had been amputated just above the ankle, and, when seen some six weeks later, in June 1937, her operative wound was well healed. The skin scar, which bisected the stump end transversely, was hyperaemic and quite tender. The tibia and fibula had been severed at approximately the same level.

The practicability of an artificial leg for so young a child seemed questionable, except to her parents. However, skepticism vanished when on December 6 she was fitted with her first prosthesis. As soon as the leg was put on, she refused the assistance of her crutches, and walked and ran about the office in a truly impressive manner. During the following two years, the fibular remnant grew more rapidly than the tibial, but caused no appreciable hindrance. In the subsequent year, disparity of growth resulted in a stump so pointed that the skin ulcerated, and it was necessary for her to go without her leg part of the time.

On March 5, 1940, the distal end of the fibula was removed, and a portion of it was secured between the bone ends (Fig. 6-A). Three months later, she resumed wearing her prosthetic leg. No subjective symptoms were complained of, but again, in approximately two years, the fibular remnant had so outgrown the tibial (Fig. 6-B) that the parents suggested a reamputation, such as had previously been performed, to prevent impending disability.

On May 19, 1942, the pointed projection joining the bones was removed, and again a small segment of bone was secured between the tibia and fibula. Within two months, the fragment of bone, which had been

placed between the bone ends, became firmly united to the fibula, but not to the tibia (Fig. 6-C). Her stump appeared quite firm, however, and she resumed wearing her prosthesis two and one-half months after the second reamputation. Firm union of the bone fragment to the tibia, although somewhat delayed, occasioned no subjective symptoms. It did make the probable outcome in this child's stump rather uncertain, however, since unequal growth in either bone could result in a bony distortion at the stump end, necessitating even a third reamputation.

She had not been seen for several months until February 19, 1944. She now has a nicely rounded, well-padded stump. The distal ends of the tibia and fibula are favorably separated and solidly bridged by bone (Fig. 6-D). The upper fibular epiphysis is at a somewhat higher level than that on the unamputated side. This is due to the difference in the increment in growth of the tibia and fibula from their upper growth centers, that of the fibula being greater than the tibia. If continued growth should cause unfavorable displacement of the fibular head, epiphysiodesis may be indicated.

This child has an excellently functioning stump. She will soon be nine years old. She is in the third grade at school where she attends the regular gymnastic classes, plays basketball, jumps rope, and participates in all the games and sports played by other children. The loss of part of a leg does not even deter her from taking tap-dancing lessons.

Although, as has been previously mentioned, excessive fibular growth may necessitate surgical intervention at the proximal end of that bone in this child, the firm cross union between the tibia and fibula at their lower ends should prevent further surgical intervention in that location.

That such a firm synostosis will prevent downward distortion in either bone in children is illustrated by the following example.

Case 3. C. J., a colored girl, had had her right leg amputated through the lower third on July 15, 1925, when she was six years old.

Four years later she was referred to the Orthopaedic Service because of pain and ulceration of her stump. The stump end was ulcerated and tapered to a point. A tender neuroma could be palpated on the posterior tibial nerve. Her stump was extremely sensitive to compression.

On November 16, 1929, a reamputation was performed. The neuroma on the posterior tibial nerve, caught in the general scar between the bone ends, was removed. The tibial and fibular remnants were cut through at approximately the same levels, and a small fragment of bone was interposed above their distal ends (Fig. 7). Other than the cleansing it received before and after operation, the ulcer was not disturbed. It healed within a few weeks.

A stump which ever since has functioned excellently resulted (Fig. 7). By using rubber sponges and felt padding inside the prosthesis, she has borne a great deal of weight on the stump end.

Case 4. In August 1923, J. L., a white man, twenty-three

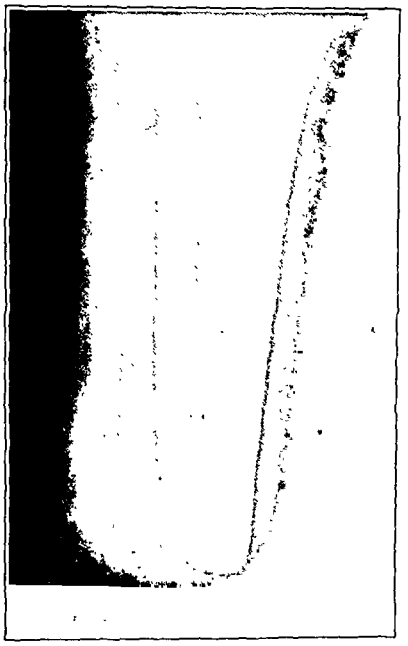

Fig. 7

Case 3. C. J. had an amputation of the right tibia and fibula. Roentgenogram shows firm bony union at the lower ends of the tibia and fibula. The tibia and fibula were cut through at approximately the same level.

Fig. 8-A

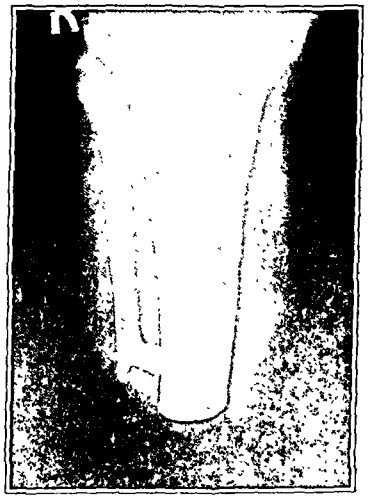

Fig. 8-B

Case 4. J. L. had an amputation of the right leg, eight inches below the knee.

Fig. 8-A: Roentgenogram taken before induced fusion.

Fig. 8-B: Roentgenogram taken eight weeks after operation, showing the fibular fragment firmly united to both bones.

years old, had his right foot amputated at the ankle following a crushing injury to his foot. Because of pain, reamputation eight inches below the knee had been performed in June 1925 (Fig. 8-A).

In January 1928, he was referred to the Orthopaedic Department because of pain and ulceration of his stump. The pain had become so intolerable when he wore his artificial leg that he was unable to work at his trade as a machine-tool operator. A sensitive ulcer, approximately one centimeter in diameter, was present near the posterior margin of the end-bearing surface. Amputation neuromata could be palpated on the peroneal and posterior tibial nerves.

Ascribing his suffering entirely to the ulceration of his stump, he for a time refused further surgical intervention. Therefore, the ulcer was treated at regular intervals for six months in the Out-Patient Department, but without benefit.

On June 18, the distal end of the fibula was cut and bent medially, so as to make contact with the tibia (Fig. 8-B). Amputation neuromata were removed from the posterior tibial and peroneal nerves, their trunks were ligated and injected with absolute alcohol. The ulcer, except for the preoperative treatment it received, was not disturbed. The operative wound healed promptly, and the ulcer, which had been present for more than two years, healed in less than one month. Firm bony union between the tibia and fibula was present at the end of eight weeks, although there was still some tenderness. The patient returned to his regular job ten weeks after the operation, wearing his artificial leg. His stump continues to function satisfactorily and has remained free from ulceration. Padding placed inside the prosthesis permits a good amount of end weight-bearing.

CONCLUSIONS

Bony union at the lower ends of the tibia and fibula, whether spontaneous or intentionally induced, stabilizes the relation of the remnants throughout their entire length. Not only are they more adaptable to pressure at their lower ends, permitting some end-bearing, but the upper tibiofibular articulation is more stable and the difficulties so commonly encountered in this region are mostly eliminated.

The method is applicable in many old bothersome stumps, or may be instituted at the time of the primary amputation. When instituted at the time of a primary amputation, other surgical principles now generally accepted for amputations below the knee should be followed.[1] In old bothersome stumps, amputation neuromata, adherent scars, ulcerations, sharply pointed bone ends, or other contributing factors should be dealt with in whatever manner they may require. In growing children, the difference of the increment in growth of the tibia and fibula from their proximal epiphyses requires special consideration.

The examples here presented were selected from some thirty odd patients, who have been seen during a period of fifteen and one-half years, to illustrate a simple means of rendering leg amputations less sensitive to the compressive force of prosthetic limbs, when employed for weight-bearing. Other patients on whom equally good results were obtained seemed dispensable to the present purpose. In general, it can be said that no serious consequences have resulted. All but a few have benefited appreciably. In but a single instance was it necessary to remove the fragment of bone which had been placed between the leg bones. In this instance, a large full-thickness skin graft, obtained from the opposite knee to cover a skin defect resulting from the excision of a large ulcer, was applied immediately following the operation on the bones. Only part of the skin graft lived, and, because of a persistent discharge, the bone fragment was removed from between the tibia and fibula a few weeks after the operation. Needless to say this patient was not benefited.

Leg amputations below the knee still present far more problems than all other amputations combined. A great deal has been accomplished in establishing better principles and procedures to ensure more suitable stumps, but opinions expressed and results observed attest the need of a continued search for even better methods.

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DISCUSSION

Colonel Leonard T. Peterson, Washington, D. C.: I have not had personal experience with spontaneous or operative synostosis of the tibia and fibula in a leg stump. This is a very interesting and valuable report and it deserves our attention. The fibula helps to stabilize the prosthesis and it is retained in most of our stumps, although excellent stumps have resulted from excision of the fibula. At present we are not justified in adopting this operation as a routine measure, but its trial in persistently painful stumps where it may relieve the pain should be considered.

Colonel Leonard T. Peterson: I heartily agree with Dr. Key (see page 350) in recommending amputation when the extremity is infected and painful, and weight-bearing does not compare favorably with the use of an artificial limb. As recently as 1940, we amputated in the case of a man partially disabled since World War I. In the Army all amputations except emergency amputations are done in five amputation centers, so that careful consideration is given each case. It is a serious matter to hospitalize an adult for two years or more for a badly damaged or infected leg, especially when the prognosis is uncertain and when he might be rehabilitated in six months by amputation of the leg.

A few rules are suggested:

1. The patient should be convinced beyond any doubt that amputation is the better choice.
2. In non-union with infection which is subsiding, amputation should not be done unless there is a very large defect or permanent nerve or vascular damage.
3. In all cases with active infection, guillotine amputation should be done just above the level of bone infection, to be followed by secondary amputation. Let me emphasize this, because amputation through the same bone with closure is very likely to lead to infection in the stump. Useful stump length should not be sacrificed because of sinuses above the level of bone involvement, since these sinuses, if opened widely at the time of guillotine amputation, will heal. In osteomyelitis of the lower tibia and the entire fibula, the latter bone may be completely resected, leaving the wound open for subsequent repair; this results in an excellent below-the-knee stump.
4. A leg stump should not be preserved if the knee is ankylosed. Too often this is done, in spite of persistent infection. If the joint is infected, a supracondylar guillotine amputation should be done.

COMMINUTED FRACTURE-DISLOCATION OF THE SHOULDER

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Twice within little more than a year the author has had occasion to operate on patients who, after a fall downstairs and a road accident, respectively, suffered from comminuted fracture-dislocation of the shoulder. The findings at operation appear to throw new light on this type of injury, and the mechanism causing it, which has not so far been accorded a detailed description. In addition, the two cases provided an opportunity for testing a variation of the time of postoperative immobilization. The method of treatment fulfilled expectations and may be found useful, since it is simple and effective.

The findings in the two cases—clinical, roentgenographic and at operation—were identical; so was the treatment and its result. Their description may, therefore, be combined with advantage.

Both patients were elderly men. One, aged seventy, had been a professional soldier and sportsman, and still had the trained strong musculature of his younger days. The other, aged fifty-seven, was a hard-working gardener.

The first had fallen down a flight of stairs in the blackout. The other had been pushed off his bicycle by a truck and had hit the curb of the road with his shoulder.

Both had been dazed and neither was able to say more about how he fell or in which position his arm was when hitting the ground.

Both complained of violent pain from the start. Swelling and bruising were far more extensive than in ordinary fractures of the upper end of the humerus.

When first seen, a few hours and two days after the accident, it was impossible to elicit signs of dislocation from clinical examination, the tense swelling rendering palpation of the head impossible. The fractures were quite obvious. The roentgenograms (Figs. 1 and 3) showed dislocation, fracture, and comminution. However, the true extent of the comminution, as found at operation, could not be seen. No axial view was taken, because of fear of causing damage to vessels and nerves which, with the possible exception of the circumflex, had escaped injury. For the same reason, no attempt at closed reduction was made. Such signs of shock as there were had disappeared when the patients were operated upon, ten hours and three days, respectively, after their accidents.

General anaesthesia and an anterior approach were used. The deltoid was found to be severely lacerated on its inner aspect. A large ragged cavity contained the fragments embedded in clot, but no fresh bleeding occurred, although the circumflex artery had been severed.

The head fragment was lying loose at the bottom of the cavity and behind the upper end of the shaft. Four other small fragments were found to be attached, each to a single muscle,—the subscapularis, supraspinatus, infraspinatus, and teres minor, respectively. The five fragments were removed. The four muscle stumps were united to the inner surface of the deltoid so as to form a muscular mantle which partly obliterated the cavity. The jagged upper end of the shaft was smoothed down. After closing the wound, the arm was put on an aeroplane splint in 80 degrees of abduction, with the elbow some 20 degrees in front of the frontal plane. The postoperative course was untroubled. The splint was left in position for five weeks in the first case, for two weeks in the second. Active exercises of the fingers, wrist, and elbow were started a few days after the operation. Massage to the shoulder began in the fourth week. Increasing movement of the shoulder was encouraged after the removal of the splint.

Apart from the first few days, there was hardly any pain, and the function of the flail joint was astonishingly good within eight weeks. Active abduction to 50 degrees became possible, and the patients soon found a way of steadying the humerus against rotation by pressing it against the chest.

When last seen, two years and one year, respectively, after operation, the first patient had been using the arm for all purposes including the carrying of suitcases, shaving, *et cetera*, without pain or weakness. The other patient had returned to gardening and was able to do everything except overhead work. He had one passing attack of pain after pushing a heavy wheelbarrow.

Mechanism of Injury

The findings at operation suggest that abduction is not responsible for this type of fracture. Severe direct violence exerted on the shell of the humeral head cracks it along the lines between muscle insertions. In the reflex contraction following contusion, each

FIG. 1
Case 1.

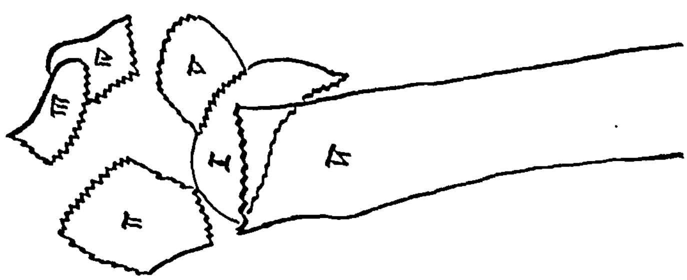

FIG. 2

I: Head fractured at the anatomical neck.
II: Subscapularis fragment.
III: Supraspinatus fragment.
IV: Infraspinatus fragment.
V: Shaft fractured at the surgical neck.

FIG. 3
Case 2.

muscle pulls away the fragment attached to its insertion, and the loose head fragment drops into the crater so created (Fig. 2).

This mechanism comes into play, if severe direct violence is exerted on the more brittle and atrophic bone around the neck of the humerus of elderly men, a condition comparable to that of the neck of the femur in elderly women. The stronger the muscles which are inserted here, the more disruptive will be the effect of the muscle contraction following the contusion. This combination of weak bone and athletic muscles appears to account for the systematic, not haphazard, type of comminution.

Treatment

The immediate choice lies between conservative methods and operation. If the general condition of the patient is bad, one may have to put the arm into a sling and leave it at that. A very stiff and painful joint is then inevitable. According to some authors, it is worth while to attempt closed reduction, if a general anaesthetic can safely be given. The author cannot see any justification for this view. The attempt is bound to fail, and is dangerous for vessels and nerves. Even if the head could be returned to the joint, it is bound to undergo avascular necrosis. In addition, it must be emphasized that the roentgenogram does not give a complete picture of the extent of comminution, owing to the overlapping of fragments.

Operation is preferable whenever the condition of the patient permits, and it ought not to be delayed unnecessarily, since scarring will make it more difficult. Of the three possible courses, open reduction and arthrodesis should not be attempted in this type of case. Open reduction, if it can be achieved at all, does not promise a painless and mobile joint. Arthrodesis is not likely to be successful, where so much of the upper end of the humerus has been destroyed. Both operations would lengthen the time considerably. Excision of fragments can be speedily done. The resulting gap looks more crippling at operation and in the roentgenograms than is the actual, final result, especially if everything is done to make the gap as short, and the fibrous scar bridging it as strong, as possible. The author believes that uniting the muscle stumps by suture helps to this end, but the essential condition for the formation of a strong, short, internal scar is to prevent the weight of the arm from stretching it. With the arm on an abduction splint, shrinkage of the scar is encouraged; the muscles bridging the gap (biceps, coracobrachialis, and deltoid) are equally relaxed, and are allowed to shorten; and unequal scar formation, which might lead to an adduction contracture, is avoided. The splint should be worn for at least four weeks. In the second case, it was discarded after two weeks, in an attempt to allow the patient to return to work as soon as possible, but actually no time was saved.

The resulting shoulder is permanently painless, has surprisingly good power, and the disability due to flailness is small. The author cannot but subscribe to the opinion of Sir Robert Jones and Lovett that this "flail" shoulder is a very useful joint indeed.

SUMMARY

In two patients, muscular elderly men, a type of comminuted fracture-dislocation of the shoulder occurred. These fracture-dislocations appeared to be due to severe violence which shattered the bone, weakened by senile atrophy, along lines between muscle insertions, and to a secondary disruption of bone by muscle pull. The patients were treated by primary excision of the fragments, followed by immobilization of the humerus on an abduction splint for several weeks. In this way, a short and strong fibrous union was obtained, giving a painless and useful arm.

QUADRICEPSPLASTY TO IMPROVE KNEE FUNCTION *

BY LIEUTENANT COLONEL T. C. THOMPSON

Medical Corps, Army of the United States

INTRODUCTION

Many people who sustain injuries to the femur or muscles of the thigh, not involving any of the structures of the knee joint itself, are handicapped for life by a permanent limitation of motion in the knee, varying from an inability to squat or kneel to a complete fibrous ankylosis.

Compound fractures of the femur produce considerable interference with quadriceps function; this is especially true of fractures due to missile injuries, and those associated with extensive soft-tissue wounds of the anterior thigh. Besides the scarring which occurs in the healing of the original injury, there is more or less fibrosis of the uninjured muscles, due to the immobilization and disuse incident to the treatment of the fracture. In fact, some restriction of knee motion may be expected after any fracture of the femur, regardless of the method of treatment employed. Any complicating factors—such as delayed union, non-union, malunion, or infection—may further limit motion of the knee and render the joint more resistant to treatment.

ANATOMICAL AND PATHOLOGICAL CONSIDERATIONS

It should be noted that the femur is almost completely surrounded by the vastus medialis, vastus intermedius, and vastus lateralis, in all of the middle third, most of the upper third, and part of the lower third. Any force severe enough to produce a fracture of the femur will inevitably injure one or all of these muscles. The rectus femoris often escapes injury, because of its smaller size and superficial position.

A full range of knee motion requires a considerable excursion of the patella to which all the components of the quadriceps muscle are attached. Scarring, fibrosis, or loss of extensibility of any one of the three deeper parts of the quadriceps will firmly anchor the patella to the femur, definitely restricting knee motion. In each of the cases in this series, it has been found that the vastus intermedius had been partially or completely replaced by a tough mass of scar tissue which effectively limited flexion. In those cases with extensive injuries or draining sinuses, the vastus lateralis, the vastus medialis, or both, had lost the greater part of their normal extensibility. Manipulation in these cases would almost inevitably have resulted in fracture of the patella.

The rectus femoris differs from the other components of the quadriceps in that it is considerably longer; it spans two joints, so that flexion of the hip relaxes it and allows freer flexion of the knee. It should be noted also that the nerve and blood supply enter the posterior surface of the muscle in the upper third of the thigh. For this reason they are usually spared at the time of the original injury, and are not endangered in the operation to be described. The degree of success to be expected in this procedure depends entirely upon whether or not the rectus femoris has escaped injury, how well it can be isolated from the scarred non-extensible parts of the quadriceps mechanism, and how well it can be developed by intensive exercise and normal use. It is the rectus femoris that normally provides the last 10 degrees of active extension of the knee, and it is the preservation of this muscle *without lengthening it* that allows early knee motion and seems to be responsible for the rapid return of active extension.

* Read at the Annual Meeting of The American Academy of Orthopaedic Surgeons, Chicago, Illinois, January 26, 1944.

OPERATIVE PROCEDURE

In order to restore as much active knee function as possible to patients with extensive scarring of the quadriceps muscle, the following procedure has been found satisfactory.

The skin incision is made in the anterior thigh, from the upper third to the lower border of the patella, varying somewhat with the positions of the scars. The fascia is divided on either side of the rectus femoris, distally from the upper third of the thigh, where the muscle is almost always normal. This muscle is then dissected free of, and drawn aside from, the vasti (Fig. 2). The vastus medialis is freed and allowed to fall to the medial side and the vastus lateralis to the outer side. The capsule is divided on either side of the patella, the incisions extending distally on both sides so that the contracture of the capsule

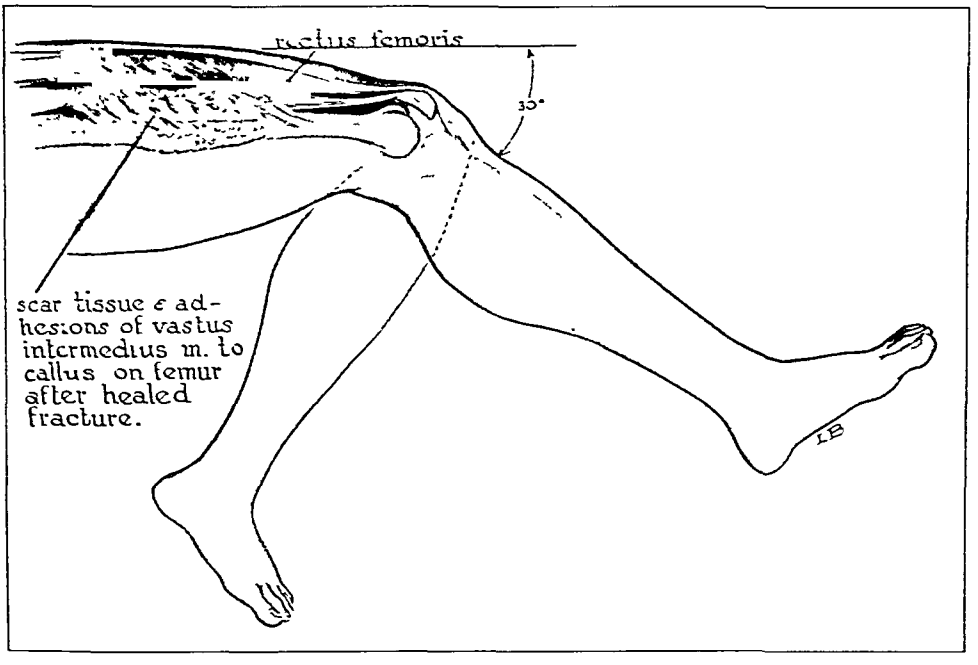

FIG. 1

Diagram showing extensive scarring and fibrosis of the vastus intermedius, restricting knee flexion to a total range of 30 degrees.

is overcome. It is usually found that the vastus intermedius is one mass of scar tissue, firmly attaching the under surface of the rectus femoris and the patella to the anterior surface of the femur. This is excised completely (Fig. 3), leaving a fibrous and periosteal covering over the front of the femur. If the compound wound has been through the front of the thigh, it is sometimes necessary to create a new rectus tendon, by making longitudinal incisions down through the scar tissue in the lower third of the thigh.

At this point, it is possible to manipulate the knee to an angle of about 70 degrees (that is, well beyond a right angle). The remaining intra-articular adhesions give way. The upper normal part of the rectus femoris will stretch out readily, and there is no danger of fracturing the patella (Fig. 4).

If either the vastus medialis or the vastus lateralis is fairly normal, it is sutured to the side of the rectus femoris down to the junction of the middle and lower thirds of the thigh. No attempt is made to close the knee capsule. If the muscles are badly scarred, they are not sutured back to the rectus. In those cases where there are old healed sinuses and multiple incisions in either the vastus medialis or the vastus lateralis, the subcutaneous tissue and fat are brought down and sutured to the femur on one side or the other of the rectus, in order to produce a new intermuscular septum and eliminate all the scarred muscle

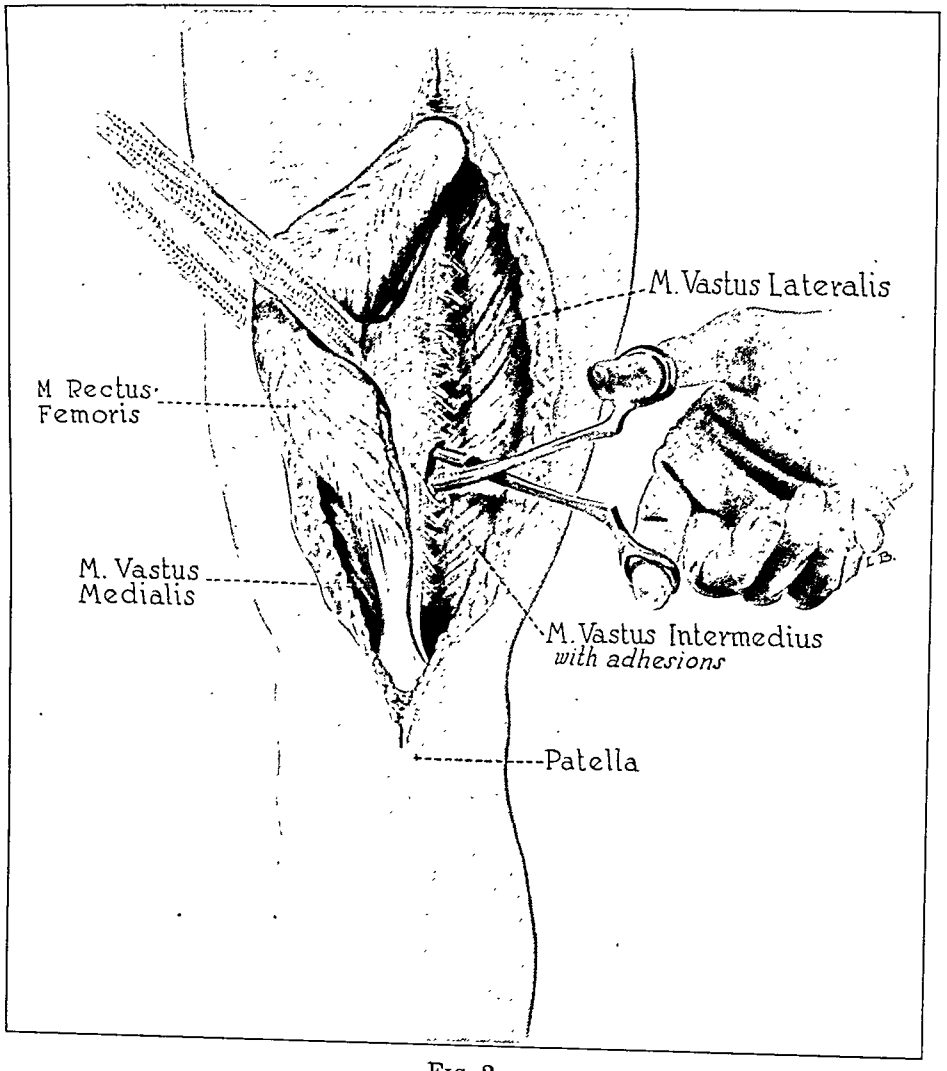

FIG. 2

Exposure of the quadriceps mechanism. The rectus femoris has been separated and retracted. The scarred vastus intermedius is being dissected out.

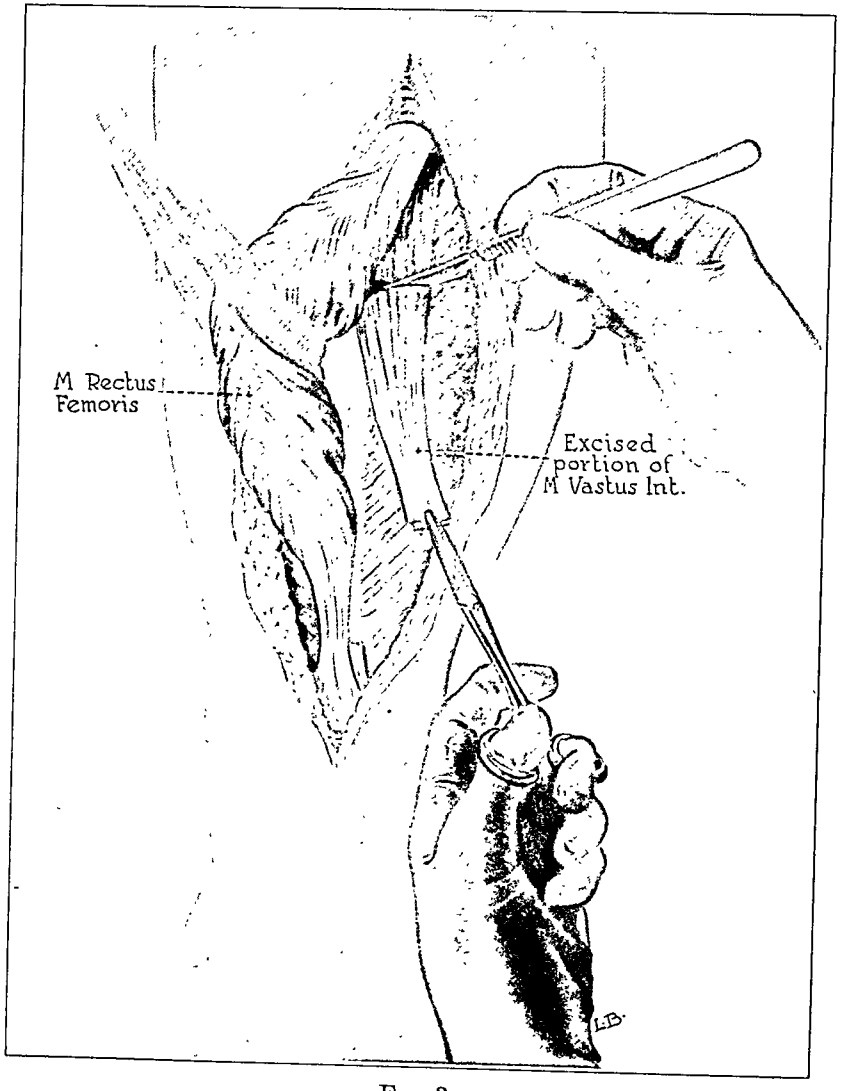

FIG. 3

The scarred, contracted portion of the vastus intermedius is being cut away.

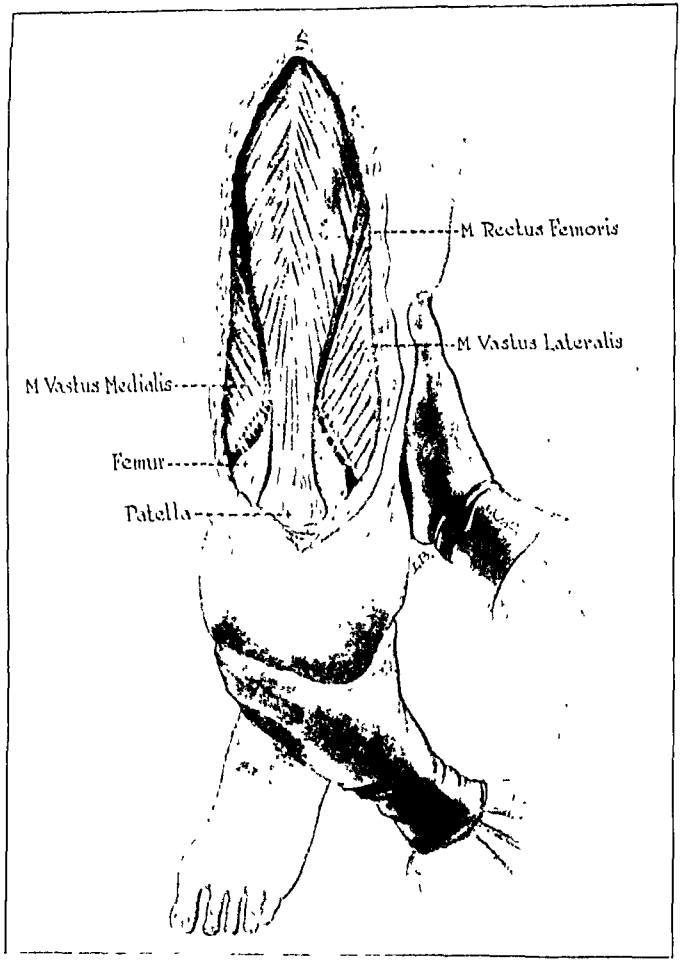

FIG. 4

After the vastus intermedius has been cut away and the vastus lateralis and vastus medialis have been freed from either side of the patella, the knee is forcibly flexed.

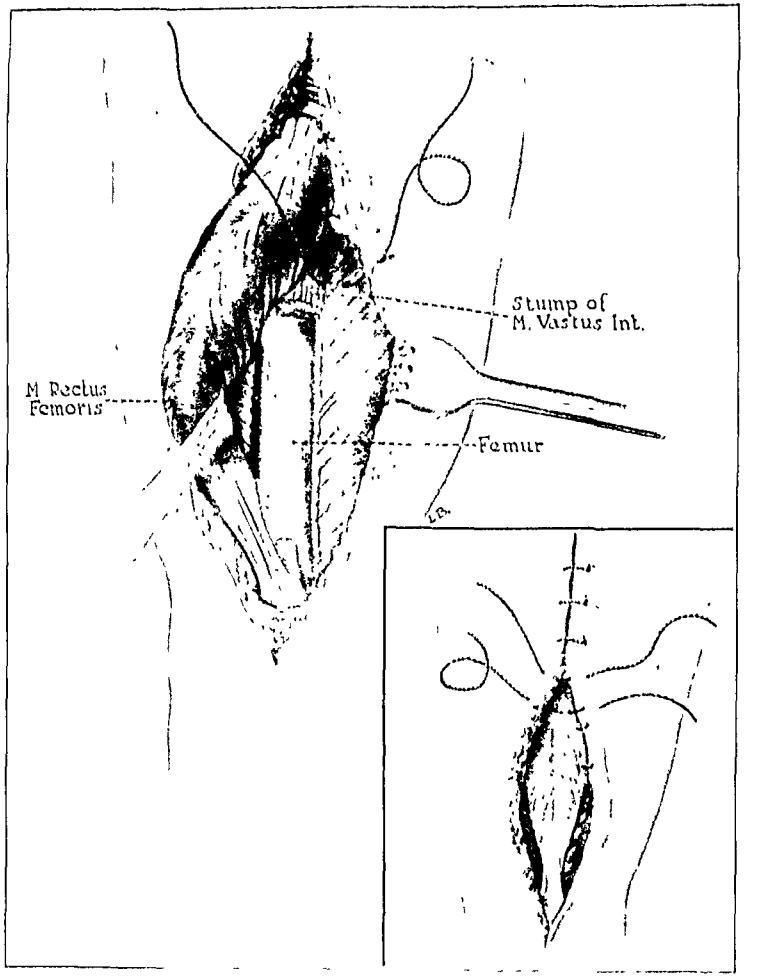

FIG. 5

Soft tissue is drawn down between the rectus femoris and the scarred vastus lateralis to produce a new intermuscular septum, and the wound is closed.

from the remaining quadriceps mechanism (Fig. 5). The skin is closed and the extremity is placed in a Thomas splint with a Pearson attachment to allow early motion.

Passive and active motion are begun immediately in balanced suspension. Recovery is surprisingly rapid. Many of these patients have 90 degrees of motion when they are removed from suspension at the end of three weeks.

It is obvious that this procedure has been developed from Bennett's quadriceps-lengthening operation. It differs, however, from his procedure in the following points:

1. The rectus femoris is isolated from the rest of the quadriceps and *not* lengthened;
2. Certain scarred parts of the vasti, especially the vastus intermedius, are excised rather than lengthened;
3. The rectus femoris is isolated as much as possible from the vastus lateralis or vastus medialis or both, if either or both muscles have been replaced by scar tissue;
4. Immobilization to allow healing of a lengthened tendon is unnecessary, and active and passive motion can be started at once.

CASE REPORTS *

CASE 1, a seaman, forty-five years old, was first seen on February 6, 1939. The diagnosis was: malunion of a simple, complete fracture of the middle third of the right femur, following an accidental injury on March 11, 1937, when the patient fell fifty feet through the manhole in the deck of a ship; chronic osteomyelitis of the right femur, secondary to open reduction of the fracture; and fibrous ankylosis of the right knee.

Examination showed that the patient walked with a limp due to stiffness of the right knee. There was shortening of three centimeters in the right lower extremity and atrophy of four centimeters in the right thigh, also a scar, twenty centimeters long, on the anterolateral surface of the thigh, with a draining sinus in the center. Motion of the right knee was from 160 to 180 degrees.

Roentgenograms showed angulation of 30 degrees at the site of the fracture, and a large, irregular, infected cavity in the femur.

First operation: On September 9, 1939, an extensive saucerization of the right femur was done through a posterolateral incision.

Eight months later the osteomyelitis of the femur, which had been present for three years, had healed. Knee motion was still from 160 to 180 degrees.

Second Operation: On February 21, 1941, a modified Bennett lengthening of the quadriceps

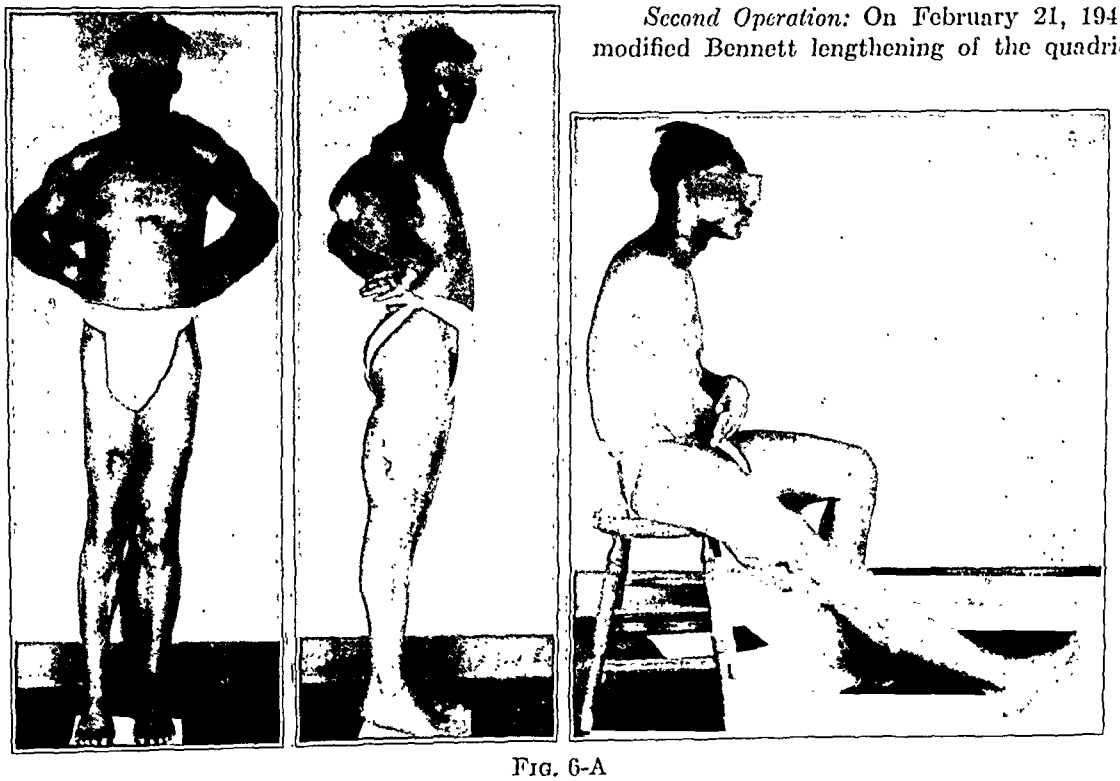

FIG. 6-A

Case 3. Before operation, there were shortening of seven centimeters in the right lower extremity, motion of only 10 degrees in the right knee joint, several scars, and two draining sinuses.

* Cases 1, 2, 3, and 12 are from the Hospital for Special Surgery, New York City.

was performed. The badly scarred vastus lateralis was separated entirely from the rest of the quadriceps, and the scarred intermedius was removed; the rectus femoris was lengthened about three centimeters and separated from the vastus medialis, as in Bennett's operation; and a flap of fat was brought down to the femur between the scarred vastus lateralis and the fairly normal rectus femoris. Flexion to 90 degrees was obtained. (This flexion of the knee could have been obtained without lengthening the rectus femoris, but, unfortunately, the muscle had already been cut.)

The patient was discharged five weeks after the operation. Passive motion was then 115 to 175 degrees. On August 18, 1941, six months after operation, passive motion was from 75 to 180 degrees and active motion, from 75 to 135 degrees. The patient walked without a limp, but could not climb stairs easily.

Although the range of motion in this case was satisfactory, active extension would probably have been much better if the rectus femoris had not been lengthened. (See Case 3, in which the pathological findings were similar.)

CASE 2, an electrician, twenty-nine years old, was admitted on March 10, 1941. The diagnosis was limitation of motion of the right knee resulting from a simple, comminuted fracture of the middle third of the right femur, accidentally incurred on October 22, 1939.

Examination showed that the patient had shortening of one and one-half centimeters in the right lower

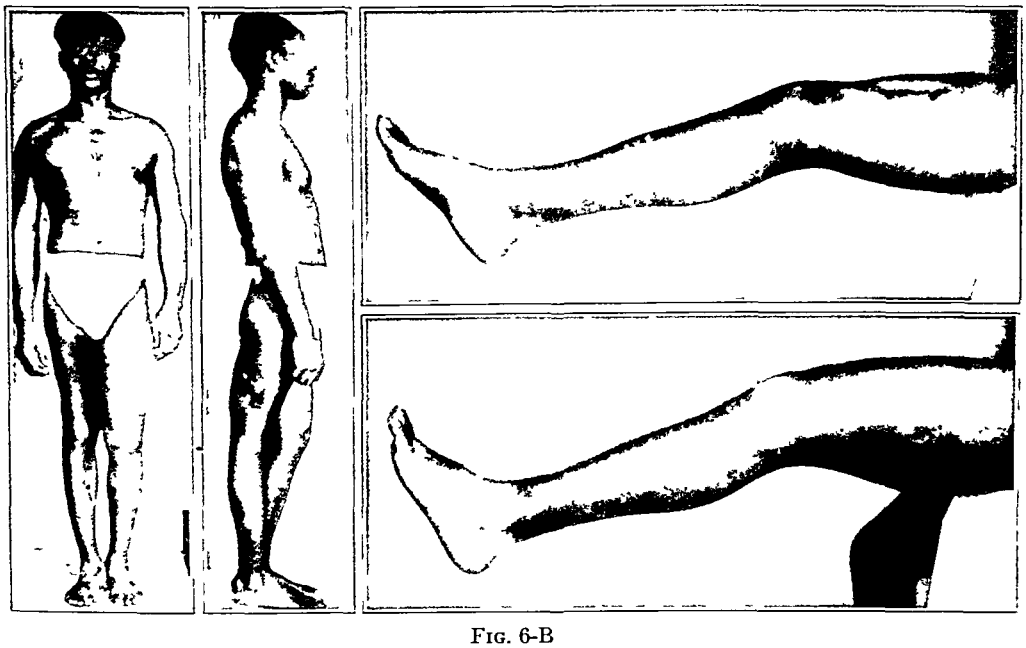

FIG. 6-B

Active extension ten weeks after quadricepsplasty on the right thigh, and eight weeks after shortening of the left femur.

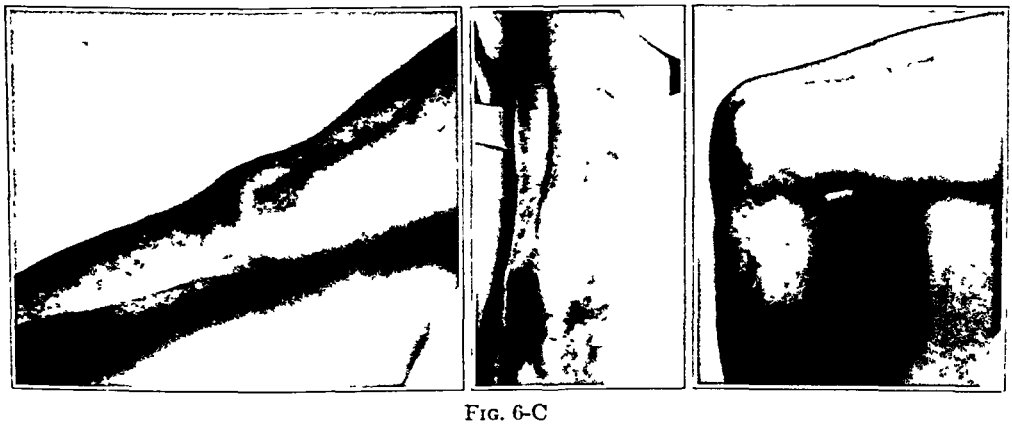

FIG. 6-C

Range of active extension and flexion of right knee, twenty months after quadricepsplasty.

extremity, but walked without a limp. There was a long, well-healed scar on the anterolateral aspect of the thigh. The right knee could not be flexed beyond 135 degrees; it locked suddenly at that point, and the patient experienced a sense of tightness in the anterior thigh.

Operation: On March 12, 1941, quadricepsplasty was performed. All muscles were normal, except the vastus intermedius which was completely replaced by scar tissue. When a large part of this tissue had been excised, and the incisions on either side of the rectus tendon had been carried down into the knee joint, the knee could be flexed to 70 degrees.

The patient was discharged on the eighteenth day after operation. Passive motion was from 100 to 180 degrees, and active extension to 165 degrees. He returned to work within a short time.

Six months after the operation there was passive motion of from 70 to 180 degrees and strong active extension to 170 degrees. Muscle power was excellent, and it was expected that the patient would regain the last 10 degrees of active extension.

CASE 3, a colored chauffeur, thirty-three years old, was admitted to the Hospital on April 16, 1941. Thirteen years previously he had sustained a gunshot injury of the right thigh, producing a badly comminuted fracture of the right femur. After three months in a plaster spica the bone had healed, with some deformity and considerable shortening, but sinuses on both the lateral and the medial sides of the thigh had drained ever since. The knee had remained stiff. On admission the diagnosis was: chronic osteomyelitis of the right femur following a compound fracture of the middle third in 1928; inequality of leg length; and fibrous ankylosis of the right knee.

Examination showed marked shortening of the right lower extremity (seven centimeters), with a secondary scoliosis, and numerous scars over the right thigh. On the anteromedial surface, at the junction of the middle and lower thirds, there was a long healed scar adherent to the femur. On the lateral side, the scar was not adherent to the bone, but there were two draining sinuses running down to the bone. There was marked atrophy of the thigh and calf. The knee joint could not be passively flexed, but it could be actively or passively hyperextended 10 degrees. (See Figure 6-A.)

First Operation: On April 18, 1941, a saucerization of the right femur was done. No extensive procedure was necessary. The operative wound healed in about five weeks.

Second Operation: On August 8, 1941, quadricepsplasty was performed on the right thigh. The medial scar and much of the scarred muscle were excised. The rectus femoris was merely dissected free from the underlying scar tissue which was densely attached to the femur and to the posterior surface of the rectus muscle. There was no real vastus intermedius remaining. After cutting well down into the capsule on either side of the patella and removing the mass of scar tissue beneath the rectus femoris, flexion to 100 degrees was obtained.

Third Operation: On August 29, 1941, a left femoral shortening of six centimeters was performed.

Six weeks after quadricepsplasty there was active extension of the right knee to 170 degrees. Six months after the third operation, active extension was still to 170 degrees. There was passive motion of from 90 to 180 degrees. The patient was able to ice skate well, and he had been able to return to his work as a chauffeur for the first time in thirteen years. (See Figures 6-B and 6-C.)

CASE 4, a private, aged nineteen years, was admitted on June 27, 1941. The diagnosis was a compound, complete fracture of the lower third of the left femur, accidentally incurred on June 24, 1941, when the motorcycle in which he was riding sideswiped an oncoming car.

Conservative treatment in the form of traction was used until August 19, 1941, when an open reduction was done and the bone fragments were fixed with a vitallium plate and six screws. Muscle tissue was found between the bone fragments. The patient was treated in suspension traction until February 10, 1942, when the plate was removed and a bone graft from the right tibia was inserted. The fracture finally united, but in October 1942 there was motion of only 30 degrees in the knee. A large bony spur was removed from the anterior surface of the femur above the fracture site, but knee motion was not improved by this procedure.

Operation: On January 14, 1943, quadricepsplasty was performed on the left thigh.

Two weeks after operation the range of passive motion was from 120 to 180 degrees. Eight weeks later the patient was discharged to full duty, with a range of motion of from 90 to 180 degrees and strong active extension to about 175 degrees. It was anticipated that function would continue to improve.

CASE 5, a sergeant, twenty-six years of age, was admitted on May 21, 1942. The diagnosis was chronic, severe, contracture of the right quadriceps muscle following a simple, complete, comminuted fracture of the right femur, sustained on December 10, 1941 (Fig. 7-A), when the motorcycle the patient was driving ran off the road and hit a tree.

The patient was treated conservatively with prolonged immobilization in a Thomas splint. Union was not solid until about ten months after injury. Motion of the knee did not improve beyond 30 degrees from complete extension, in spite of repeated exercise and physiotherapy (Figs. 7-B and 7-C).

Operation: On February 9, 1943, quadricepsplasty was performed on the right thigh, and flexion to an angle of 70 degrees was obtained.

The patient regained function rapidly, and three weeks after operation he was allowed out of balanced

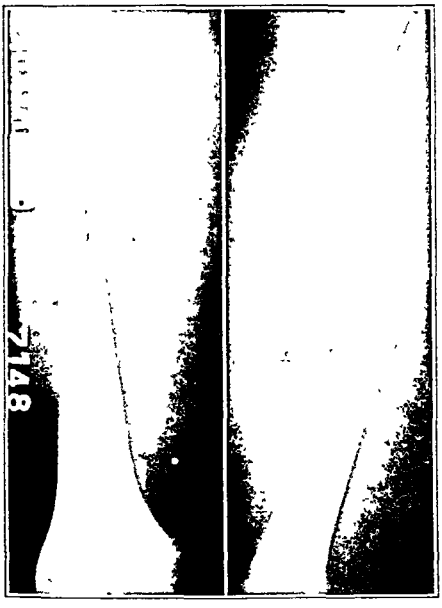

FIG. 7-A

Case 5. Simple, comminuted fracture of the femur.

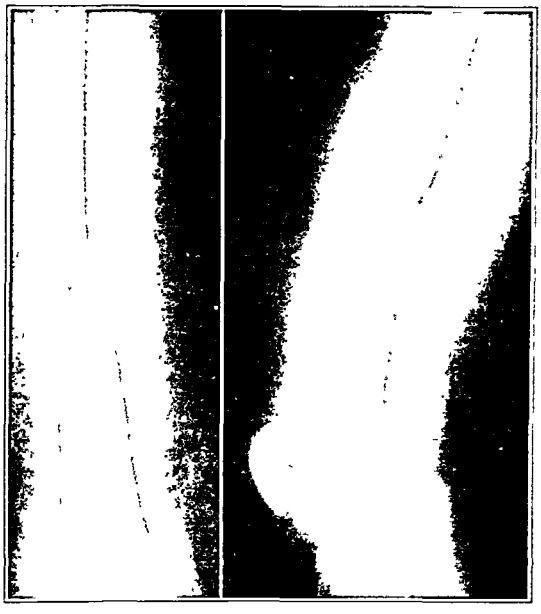

FIG. 7-B

Delayed union required many months of treatment in traction.

FIG. 7-C

FIG. 7-D

FIG. 7-E

Fig. 7-C: Maximum knee flexion after fourteen months.

Fig. 7-D: Flexion of the knee seven weeks after quadricepsplasty.

Fig. 7-E: Active extension seven weeks after quadricepsplasty.

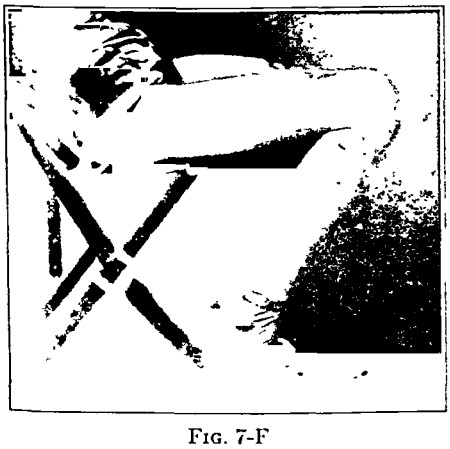

FIG. 7-F

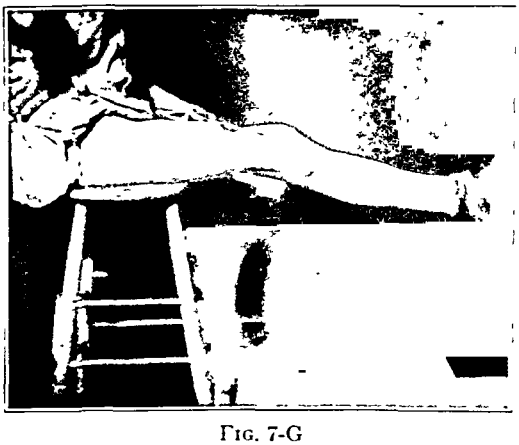

FIG. 7-G

Flexion and active extension eighteen weeks after quadricepsplasty.

traction. Seven weeks after operation there was flexion to 90 degrees, and strong active extension to 165 degrees (Figs. 7-D and 7-E). The patient was discharged to limited duty on June 23, 1943, nineteen weeks after operation (Figs. 7-F and 7-G). He was seen again, about eight months after operation, and returned to full military duty with a range of passive motion of from 60 to 180 degrees and strong active extension to 170 degrees.

CASE 6, a sergeant, aged twenty-one years, was admitted on March 17, 1943. The diagnosis was severe limitation of motion of the left knee, following a fracture of the middle third of the left femur, accidentally incurred on October 27, 1941, when the patient had been thrown from a motorcycle.

Operation: On March 30, 1943, quadricepsplasty was performed on the left thigh.

The patient was discharged from the Army on August 19, 1943, because he was unable to do full duty. At that time he had a range of motion of from 90 to 180 degrees, and strong active extension.

CASE 7, a private, aged twenty-four years, was admitted on April 23, 1943, with a diagnosis of limitation of motion of the right knee, secondary to a simple, complete, fracture at the junction of the middle and lower thirds of the right femur, accidentally incurred in a motorcycle accident on August 4, 1941, with paralysis of the right common peroneal nerve.

The fracture had been treated by traction, with a pin through the lower end of the femur which apparently had injured the peroneal nerve. The fracture had healed after prolonged treatment with skin traction, but knee motion had not increased beyond 40 degrees (Figs. 8-A and 8-B). Foot-drop was also present, due to the injury to the peroneal nerve.

First Operation: On May 14, 1943, the peroneal nerve was explored, and considerable scarred tissue around it was removed. This operation caused immediate improvement in sensation and power in the muscles supplied by the peroneal nerve.

Second Operation: On June 10, 1943, quadricepsplasty was performed on the right thigh.

Balanced suspension was continued for three weeks, and the patient used crutches for an additional two weeks. Fifteen weeks after operation the patient returned to full duty, with passive motion of from 70 to 180 degrees, and with strong active extension. (See Figures 8-C, 8-D, 8-E, and 8-F.)

CASE 8, a private, aged twenty-eight years, was admitted on June 25, 1943. The diagnosis was: simple, complete fractures of the right femur, the left femur, and the upper left tibia, accidentally incurred on March 27, 1942, when the jeep in which the patient was riding struck a tree.

FIG. 8-A

Case 7. Simple fracture of the femur. Delayed union required immobilization for eight months.

FIG. 8-B

Solid bony union twenty-one months after injury. Knee motion of only 40 degrees.

Examination showed that the patient had recovered fairly well from his severe injury. Roger Anderson apparatus had been used bilaterally for a time, and there were deep scars along the lateral aspect of both thighs. Motion in the right knee was from 90 to 180 degrees and in the left, from 140 to 180 degrees. There was considerable crepitation and pain on motion in both knees. (See Figure 9-A.)

Operation: On August 13, 1943, quadricepsplasty was performed on the left thigh, and a foreign-body cyst was removed from below the left knee.

Two weeks after operation the patient had almost 90 degrees of painless motion. Four weeks later, he was allowed to go on furlough. Eleven weeks after operation the patient had strong active motion, from 90 to 180 degrees (Figs. 9-B and 9-C).

CASE 9, a sergeant, aged twenty-six years, was admitted on January 27, 1943. The diagnosis was: a simple, complete fracture of the lower third of the left femur; a simple, complete, compression-type fracture of the first lumbar vertebra, with traumatic myelitis; and multiple compound fractures of the skull and head. The injuries had been sustained in a glider crash on December 8, 1942.

Skeletal traction was attempted for four weeks; then open reduction of the fracture of the left femur was performed without internal fixation. The patient had arrived at the hospital in a body spica, with considerable posterior bowing of the femur at the site of fracture. Because of the multiple injuries, the fractures of the spine and femur were immobilized in plaster. On July 1, 1943, union of the fractured femur was solid, but there was only 30 degrees of motion in the left knee.

First Operation: On August 20, 1943, quadricepsplasty on the left thigh was performed, and motion of from 80 to 165 degrees was obtained. There were dense adhesions in the knee joint, and the quadriceps pouch was practically obliterated.

Three weeks after operation the patient was allowed up on crutches. There was passive motion of from 90 to 180 degrees and active extension to 150 degrees. Eleven weeks after operation there was passive motion of from 80 to 180 degrees. Active extension, however, had not increased, and apparently adhesions had re-formed between the under surface of the rectus tendon and the anterior surface of the femur.

Second Operation: On November 17, 1943, the wound was again explored under local anaesthesia, and numerous long adhesions between the rectus muscle and the femur were removed. A sheet of tantalum foil, eight by twelve centimeters in size, was sutured to the anterior surface of the femur just above the condyles, in an attempt to prevent re-formation of adhesions. At this time, active extension was increased from 150 to 165 degrees.

Two months later, the patient still had very poor active extension of the knee joint. This may have been due in part to the paraplegia and weakness of all the leg muscles, but it was also partly due to re-formation of adhesions in the knee joint, suprapatellar pouch, and quadriceps mechanism. Although there has been considerable gain in passive motion, the procedure has not produced satisfactory results in this case.

CASE 10, a private, twenty-two years of age, was admitted on April 27, 1943. The diagnosis was: pene-

FIG. 8-C

Degree of motion in knee joint eight weeks after quadricepsplasty.

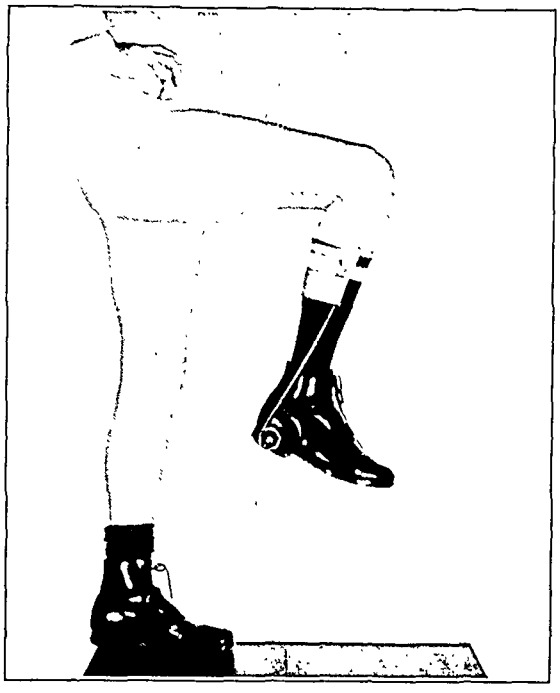

FIG. 8-D
Flexion fifteen weeks after operation.

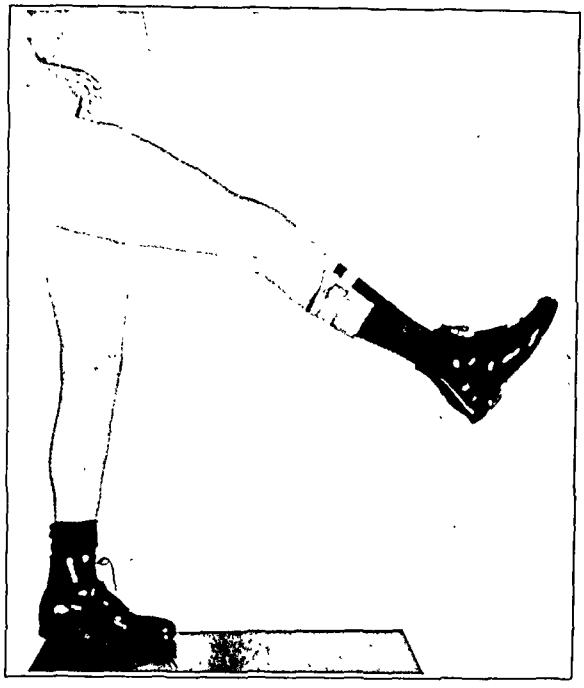

FIG. 8-E
Extension fifteen weeks after operation.

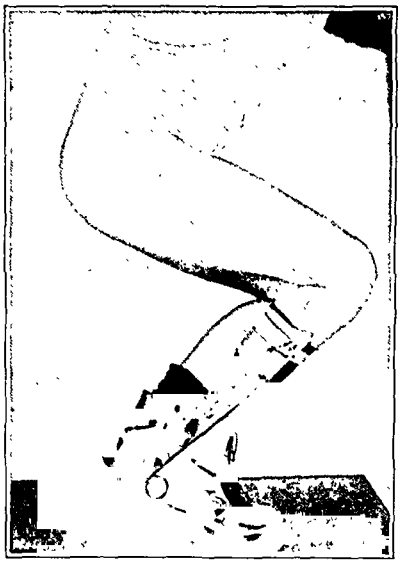

FIG. 8-F
Squatting position fifteen weeks after operation.

trating wounds of the right thigh on the anterolateral surface, and of the right knee, lateral and distal to the patella; compound fractures of the right patella (comminuted, complete), and of the lower third of the right femur (incomplete); and multiple wounds of the left thigh and lower leg, all the result of a shrapnel injury, accidentally incurred on November 10, 1942. The patient had received very little immediate treatment, and a plaster cast had been used most of the time until February 15, 1943.

Examination on admission showed that the patient had marked limitation of motion in the right knee. It could be flexed to an angle of 140 degrees, and extended to about 170 degrees. Intensive physiotherapy did not improve the motion, and scar excision was done on May 18, 1943.

Operation: On August 27, 1943, quadricepsplasty was performed on the right thigh, and the knee was manipulated in flexion to an angle of 80 degrees.

The patient improved slowly after operation. He was discharged from the Army, December 31, 1943, with passive motion of from 100 to 178 degrees and with active extension to about 175 degrees.

CASE 11, a captain, aged thirty-three years, was admitted on June 28, 1941. The diagnosis was: non-union of a compound, comminuted, subtrochanteric fracture of the right femur, with coxa vara deformity and shortening of six centimeters; partial fibrous ankylosis of the right knee; and chronic osteomyelitis. The injury had been incurred accidentally on May 12, 1939, the result of a 12-gauge shotgun wound.

Examination showed marked shortening of the right lower extremity, with coxa vara. There was only 5 degrees of motion in the right knee. There were draining sinuses over the anterior and lateral aspects of the upper third of the right femur.

First Operation: In July 1941, the sinus tract was incised, and a plate and screws were removed. A Kirschner wire was inserted in the lower end of the right femur and thirty-five to forty pounds of traction was applied.

Second Operation: In August 1941, the sinus tract was excised and the wound closed.

Third Operation: On November 6, 1941, an autogenous bone graft was placed across the area of non-union, with the coxa vara well corrected.

The patient was discharged on October 24, 1942, able to bear full weight without a brace, but with motion of only 5 degrees in the right knee.

The patient was readmitted on August 17, 1943. At this time the femur was solid and all scars were

well healed, but there were deep, adherent scars in the upper and middle thirds of the thigh, on the anterior and lateral aspects.

Fourth Operation: On August 28, 1943, quadricepsplasty was performed on the right thigh. In this case, the scarring was in the upper and middle thirds of the femur, rather than in the lower third, and the rectus muscle had been almost entirely replaced by scar tissue. It was dissected away from the anterior surface of the femur in the upper third and it was allowed to remain attached to the vastus medialis at this point. The usual incisions were made on either side of the rectus tendon in the lower part of the thigh, and the knee was manipulated to an angle of about 80 degrees. The upper part of the rectus muscle would not stretch out, but the rectus tendon remained attached to the vastus medialis at the junction of the middle and upper thirds of the thigh. It was hoped that this connection might provide some extensor power. The soft tissue was brought down to the femur, lateral to the rectus muscle, throwing the scarred vastus lateralis completely out of the quadriceps mechanism.

Passive motion in the knee improved gradually, but at best it was only from 120 to 175 degrees. Nine weeks after operation, while on sick leave, the patient developed a high fever and a chill, and the next day he began to have acute pain in the knee joint. There was no other definite sign of infection, but the temperature remained moderately elevated and the sedimentation rate varied from normal to thirty-two millimeters in one hour. The knee was immobilized for a period of six weeks, and symptoms gradually subsided. On January 10, 1944, he was discharged on sick leave, with painless motion of from 140 to 165 degrees.

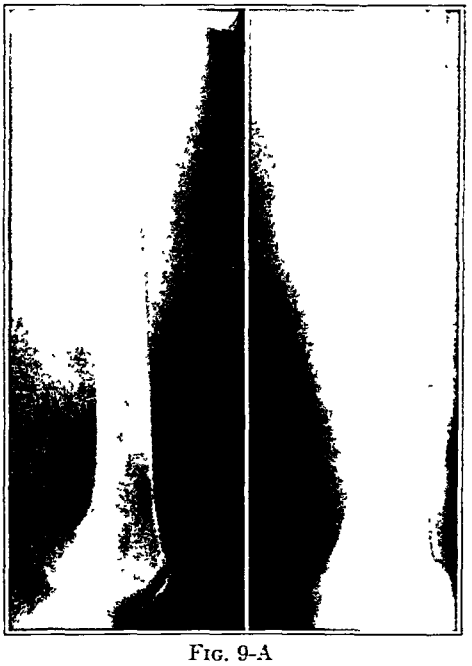

FIG. 9-A

Case 8. Fifteen months after a simple fracture of the left femur. Knee motion was only 40 degrees.

This patient will probably improve considerably, but the result of the operative procedure is now, and may continue to be unsatisfactory, because of the fact that the rectus muscle was almost completely destroyed by the original injury and subsequent infection.

CASE 12, a white woman, twenty-four years old, was admitted on December 16, 1943, because of difficulty in walking. The diagnosis was: ankylosis of both hips; stiffness of the right knee, due to contracture and scarring of the quadriceps following healed osteomyelitis of the right femur; and recurvatum of the right knee.

At the age of seventeen the patient had developed an infection in the region of both hips which resulted in complete ankylosis. Numerous operations for the osteomyelitis had been necessary, and, at the age of twenty, an osteotomy of the left femur had been done. Her main complaint was the inability to flex the right knee and a knock-knee deformity on the right side.

Examination showed a well nourished woman who stood with an extreme lumbar lordosis. There were

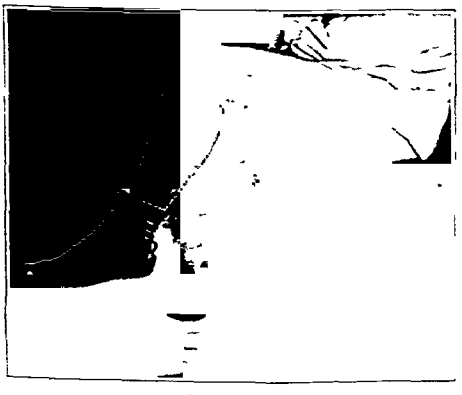

FIG. 9-B

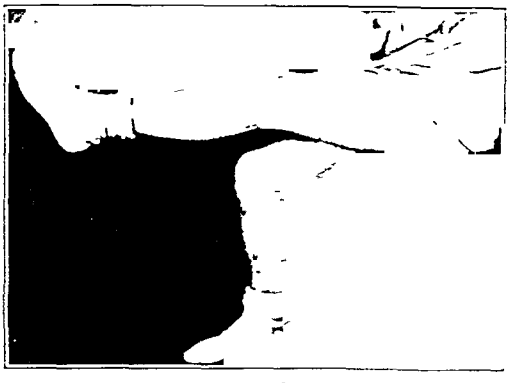

FIG. 9-C

Flexion and active extension eleven weeks after quadricepsplasty.

numerous scars about both hips. She walked by swinging her pelvis. There was flexion deformity of 70 degrees in each hip. The right knee showed a recurvatum deformity of 20 degrees, and there was flexion to an angle of about 165 degrees.

Operation: On December 19, 1943, quadricepsplasty was performed by Dr. Ralph Rowen. It was found possible to flex the knee to 90 degrees after separating the quadriceps mechanism. In this case, a Z type of plastic lengthening of the vastus intermedius was done.

Three weeks after operation the patient was able to flex the knee to 90 degrees, and she had active extension to 180 degrees in the swimming pool but not against gravity. Considerable further improvement is expected.

CASE 13, a private, aged twenty-six years, was admitted on April 27, 1943. The diagnosis was partial paralysis of the left median and ulnar nerves and scar of the biceps muscle, following a complete fracture of the left humerus and a machine-gun wound of the upper part of the left arm, accidentally incurred on January 31, 1943.

Examination showed marked restriction of motion in the left elbow; two draining sinuses in the left arm; and numbness of the second, third, and fourth fingers. The fracture was not solidly united.

First Operation: On July 31, 1943, a neuroma was removed from the median nerve, and the nerve was sutured with tantalum wire and wrapped with tantalum foil. The ulnar nerve was explored and a few adhesions were released. The motion in the elbow did not improve, but remained from 45 to 100 degrees in spite of intensive physiotherapy.

Second Operation: On September 29, 1943, the anterior scar in the lower left arm was widely excised. The biceps muscle was explored and a scar, extending through the center of the biceps and brachialis muscles, was carefully removed. The elbow could then be extended to 170 degrees. Early active motion was begun, and the patient continued to have an excellent range of motion in the left elbow.

CASE 14, a private, twenty years of age, was admitted on November 23, 1943. The diagnosis was limitation of extension following a simple, complete, posterior dislocation of the right elbow, accidentally incurred on July 2, 1943.

Examination showed no gross deformity of the right elbow, which had full flexion, pronation, and supination but could not be extended beyond 90 degrees. When attempts were made to force extension of the elbow, a depression appeared over the upper part of the forearm, in the origin of the flexor muscles, and the patient complained of pain radiating down the median nerve.

Operation: On December 6, 1943, an extensive exploration of the anterior surface of the elbow was carried out, with excision of a large mass of scar tissue which included a considerable part of the origin of the pronator teres and the flexors of the fingers, and a large part of the brachialis muscle. The median nerve was embedded in this scar mass, and considerable care was needed to dissect it out. As soon as the scarred tissue had been completely removed, extension to 165 degrees was obtained.

The patient was relieved of all nerve symptoms, and function of the elbow has continued to improve.

DISCUSSION

The results were considered satisfactory in ten of the twelve cases operated upon for stiff knees. In one patient (Case 9), who had a fractured spine with partial paraplegia as well as a fracture of the femur, a good range of passive motion was obtained, but voluntary extension was not restored because of muscle weakness and re-formation of adhesions in the quadriceps pouch. In another instance (Case 11), the scarring in the quadriceps was so extensive that the little normal muscle that remained could not be made to function satisfactorily. Even though active extension was not restored, both of these patients felt that the operation had been worth while, because of the improvement in passive motion.

When it is possible to remove the greater part of the scarred muscle and start early active motion, the patient can be expected to regain an excellent degree of active and passive motion in the knee joint. It is our opinion that the main reason for success in these cases is leaving the rectus femoris intact and *not lengthening* it.

When scarring has been very extensive and very little normal muscle can be saved, the results have been less satisfactory. Occasionally adhesions will re-form. Even in these cases, however, there has been considerable improvement in function. It is possible that interposition of some non-irritating material, such as vitallium or tantalum, may partially prevent this.

The principle of radical excision or isolation of scarred or fibrosed muscle for the purpose of allowing the remaining normal muscle tissue to function has been applied to

the deltoid muscle, to the biceps brachii, and to the brachialis and flexor muscles of the forearm in the region of the elbow (Cases 13 and 14).

CONCLUSIONS

1. Restriction of knee motion is common after injuries to the thigh.
2. Quadriceps function may be restored by operative procedure.
3. The principle of excision of scarred tissue to allow normal muscle tissue to function can frequently be used to improve motion in other major joints.

DISCUSSION

DR. ROBERT W. JOHNSON, JR., BALTIMORE, MARYLAND: I know that Colonel Thompson would prefer to have Dr. Bennett discuss this paper, as he was the originator of the quadriceps-lengthening procedure,* but in Dr. Bennett's unavoidable absence I am happy to pinch hit and congratulate Colonel Thompson on his practical modification and reduction of the rather extensive procedure originally proposed. His moving pictures show conclusively how successful he has been in dealing with these cases which he is reporting. It is probable that this procedure is all that will be needed in quite a fair proportion of cases of stiff knee. However, from observation of Dr. Bennett's cases (I have done none myself), I know that there are also many cases in which the vasti are tremendously scarred, and a much more extensive dissection has been required to secure initial liberation. Naturally, because of the greater muscle scarring in these severe cases, the end result was both longer delayed and less functionally fine than in Colonel Thompson's cases. I feel that Colonel Thompson has made a real addition to the subject by demonstrating the desirability of flexibility in operative procedures, as well as in knee joints.

DR. J. ALBERT KEY, ST. LOUIS, MISSOURI: In the past I have used the Bennett or Jones method of quadriceps lengthening in these cases, but when Colonel Thompson told me of his method, it immediately struck me as logical and I have used it on one case. However, it is to be emphasized that the principal factor in preventing flexion at the knee in these old cases is not adhesion of the quadriceps to the femur, but is the thickening and contracture of the tissues lateral to the patella and uniting the superior and lateral portions of the patella to the condyles of the femur. In certain instances this tissue is over one-half of an inch thick and it must be divided in order to flex the knee; when it is divided it cannot be adequately closed by any plastic procedure, other than a free graft of fascia which I have not used.

In the past, I have split the quadriceps tendon in a frontal plane and partially closed the gap left when the lateral capsule had been cut at the upper border of the patella.

In performing the operation as described by Colonel Thompson, I have not attempted to free the deeper layer of the muscle from the femur, but have lifted up the rectus femoris and cut the deeper portion of the quadriceps tendon directly across and have then extended the incision laterally on either side around the patella down to the distal portion of the condyles of the femur. This permits flexion of the knee and lessens the danger of recurrence of adhesions between the femur and the deep layer of the quadriceps tendon.

* Bennett, G. E.: Lengthening of the Quadriceps Tendon. J. Bone and Joint Surg., IV, 279, Apr. 1922.

THE USE OF PENICILLIN IN THE NAVY *†

BY JOSEPH S. BARR

Captain, Medical Corps, United States Naval Reserve

In July 1943, sufficient quantities of penicillin were made available to the Navy to permit supplying ten Naval Hospitals with limited amounts of this new and powerful antibiotic agent. Other hospitals were added to the list within the next few months as additional allotments of penicillin were made.

In a letter of instruction to the Medical Officers in command of these hospitals, the Surgeon General directed that there be prepared and forwarded to the Bureau of Medicine and Surgery for statistical evaluation a summary of each case treated with penicillin. The letter further stated,

"In order to make the best use of this drug, it is directed that a 'Penicillin Service' or 'Penicillin Team' be established in each hospital receiving allotments of the drug. The Medical Officer to be in charge of this service and his assistants should be selected with careful consideration of their fitness for such an undertaking. The Medical Officer in charge should be given full responsibility for the use of penicillin in all units of the hospital. It shall be his duty to acquaint himself and his associates with all available data on the use of penicillin and to keep informed of current developments; to select cases after due consultation; to supervise administration; to observe and record results and to render the reports indicated in this letter."

This paper is an attempt to summarize the 1,976 case reports received in the Bureau of Medicine and Surgery prior to January 1, 1944.

No serious reactions or untoward effects attributed to the use of penicillin were reported in the 1,976 cases.

SELECTION OF CASES

The recommendations of the Committee on Chemotherapy of the National Research Council have, in general, been closely adhered to in the selection of cases, but it has never been the policy of the Bureau of Medicine and Surgery to dictate to its Medical Officers in the field the exact methods of treatment to be followed in any given case. There are included a few reports of cases which probably should not have been selected for treatment with penicillin.

METHOD OF TREATMENT

The drug was administered intramuscularly, intravenously, locally, and, in three instances, by duodenal tube. It is known that penicillin is inactivated by gastric juice. Administration by mouth or by rectum is ineffectual.

The gonorrhoea cases resistant to the sulfonamides treated by intramuscular injection showed a slightly higher percentage of success than those treated by intravenous injection (98.2 per cent. as against 94.0 per cent.). Although this difference is statistically significant, no deductions are made from this observation because all the failures by intravenous therapy occurred at one Naval Hospital. Further studies are under way to attempt to ascertain which of these two methods of administration is the better.

Although dosage of penicillin in line with the recommendations of the National Research Council was suggested by the Bureau of Medicine and Surgery, exact treatment schedules were left to the discretion of the Medical Officer in charge of the case. As a result, dosage varied widely. A study of the case reports appears to offer little new information on the exact dosage required to effect a cure in a given case.

* Read at the Annual Meeting of The American Academy of Orthopaedic Surgeons, Chicago, Illinois, January 25, 1944.

† This article has been released for publication by the Division of Publications of the Bureau of Medicine and Surgery of the United States Navy. The opinions and views set forth are those of the writer and are not to be considered as reflecting the policies of the Navy Department.

The Bureau of Medicine and Surgery's most recent recommendations to its Medical Officers are that penicillin be administered either continuously by the intravenous route, or intramuscularly every three hours night and day. The average recommended daily dose is 60,000 units if the intravenous route is used, and 120,000 units if the intramuscular route is elected. It is important that early treatment be intensive and the dosage be adequate.

For critically ill patients, combined intravenous and intramuscular penicillin therapy for the first twenty-four hours may be necessary, a maximum of 240,000 units being given by each route during that interval.

In mixed infections, better results may be obtained by using penicillin and sulfonamide therapy concurrently than would be the case if either were used alone.

Frequently repeated blood transfusions appear to be of marked value in reinforcing the patient's hemopoietic system.

Topical application in soft-tissue wounds and in osteomyelitis appears to be of therapeutic value. It may be applied in saline compresses containing 250 units per cubic centimeter of solution. The solution should be trapped at the site of the lesion, and should be renewed every six to eight hours. Simple irrigation is not effective.

CRITERIA FOR ASSESSMENT OF RESULTS

Let us examine briefly the results thus far obtained from the use of penicillin in the treatment of Naval personnel suffering from a variety of infections. Only three categories were allowed for the assessment of the result of treatment with penicillin.

Success: The patient was cured or the course of the disease was so dramatically changed for the better that there could be no doubt of the specific effect of penicillin.

Failure: Penicillin had no apparent effect on the course of the disease.

Indeterminable: Cases showing mild or moderate improvement, questionably due to the use of penicillin, are placed in this group. Patients who recovered, but without radical alteration attributable to the use of penicillin in the course of the disease, are also listed in this group.

RESULTS OF TREATMENT CLASSIFIED BY DISEASES

Sulfonamide-Resistant Gonorrhoea (Tables I and II)

Although the sulfonamide treatment of Neisserian infection has been hailed as a revolutionary scientific advance in specific therapy, the fact is that, in a considerable percentage of cases, sulfonamide treatment fails to cure. This percentage of failure has been variously estimated at from 10 to 30 per cent. of the cases.

Penicillin is being used in the treatment of these sulfonamide-resistant cases with results that may conservatively be called dramatic. Out of a total of 1,750 case reports of sulfonamide-resistant gonorrhoea treated with penicillin, 1,701 or 97.2 per cent. were cured by one course of treatment. On re-treatment, thirty-one additional successes are recorded. The final report on these cases shows 99 per cent. cure, 1 per cent. failure. The criteria for cure are strict, including complete subsidence of all clinical signs and symptoms along with bacteriological sterilization of the involved genito-urinary tract. There can be no question that a new, most powerful weapon against this venereal disease is now available.

Diseases Due to Other Organisms (Table III)

In 149 cases, other than gonorrhoea, the type of organism was reported, identified by either culture or smear. Table III summarizes the results obtained for each type of organism. Although the number of cases of any particular organism reported in this series is not large, the results are strikingly similar to those reported by other investigators. Staphylococcus aureus, streptococcus hemolyticus, pneumococcus, and meningococcus infections seem to show the most favorable response to penicillin therapy. Four cases of

TABLE I

SUMMARY OF CASES OF GONORRHOEA RESISTANT TO THE SULFONAMIDES AND TREATED WITH PENICILLIN AT NAVAL HOSPITALS

Naval Hospital	No. of Cases Treated					Average Dosage per Case Treated (*Units in Thousands*)			
	Total	Intramuscular	Intravenous	Other	Method Not Specified	Intramuscular	Intravenous	Other	Method Not Specified
Bainbridge, Maryland	59	—	—	—	59	—	—	—	133
Bethesda, Maryland	152	90	61	1*	—	106	101	75	—
Chelsea, Massachusetts	90	90	—	—	—	120	—	—	—
Corpus Christi, Texas	16	14	2	—	—	111	50	—	—
Great Lakes, Illinois	206	206	—	—	—	163	—	—	—
Key West, Florida	5	—	—	—	5	—	—	—	100
Long Beach, California	64	—	—	—	64	—	—	—	105
Mare Island, California	58	—	58	—	—	—	105	—	—
Oakland, California	10	7	—	3†	—	228	—	117	—
Pearl Harbor (Aiea Heights)	32	—	5	—	27	—	160	—	160
Philadelphia, Pennsylvania	54	—	54	—	—	—	408	—	—
Portsmouth, Virginia	210	210	—	—	—	115	—	—	—
St. Albans, New York	226	107	—	—	119	133	—	—	108
Sampson, New York	51	—	—	—	51	—	—	—	61
San Diego, California	270	147‡	—	—	123	75	—	—	60
Seattle, Washington	247	28	219	—	—	128	153	—	—
Total	1,750	899	399	4	448	122	172	107	95

* Gonorrhoea of the knee joint, penicillin injected into the knee.
† Intraduodenal injection.
‡ Includes ten cases reported as "experimental research", not proved resistant to the sulfonamides.

TABLE II

RESULTS OF TREATMENT OF CASES OF GONORRHOEA, RESISTANT TO THE SULFONAMIDES, WITH PENICILLIN AT NAVAL HOSPITALS

Naval Hospital	Total	No. of Successes								No. of Failures			
		Intramuscular		Intravenous		Other		Method Not Specified					
		Original Treatment	Retreatment	Original Treatment	Retreatment	Original Treatment	Retreatment	Original Treatment	Retreatment	Intramuscular	Intravenous	Other	Method Not Specified
Bainbridge, Maryland	59						–	59	0			–	0
Bethesda, Maryland	152	89	0	59	2	0	0		-	1	0	1	
Chelsea, Massachusetts	90	90	0							0		–	–
Corpus Christi, Texas	16	11	0	1	1					0	0	–	
Great Lakes, Illinois	206	201	0							2			
Key West, Florida	5							5	0		-		0
Long Beach, California	64							62	0		–	–	2
Mare Island, California	58			58	0						0	–	
Oakland, California	10	7	0			2	1			0	–	0	
Pearl Harbor (Aiea Heights)	32			5	0			27	0	-	0	–	0
Philadelphia, Pennsylvania	54			52	2						0	–	–
Portsmouth, Virginia	210	207	2							1	–	–	–
St. Albans, New York	226	106	0					115	1	1	–	–	0
Sampson, New York	51							51	0	–	–	–	0
San Diego, California	270	139	8			–	-	122	0	0	–	–	1
Seattle, Washington	247	27	1	200	10	–	-	-	–	0	9	–	–
Total { No.	1,750	883	11	375	15	2	1	111	1	5	9	1	3
Total { Per Cent.*	100 0	98 2	1 2	91 0	3 7	50 0	25 0	98 1	0 9	0 6	2 3	25 0	0 7

* Percentages are based on the total number of cases treated by each method

TABLE III

SUMMARY OF DISEASES (OTHER THAN GONOCOCCAL INFECTIONS) TREATED WITH PENICILLIN AT NAVAL HOSPITALS, CLASSIFIED ACCORDING TO ETIOLOGICAL AGENT

Etiological Agent	No. of Cases Treated	Average Dosage per Case (*Units in Thousands*)	Results of Treatment		
			Success	Failure	Indeterminable
Actinomyces madurae	1	3,620	0	0	1
Bacillus coli	2	225	0	2[a]	0
Coccidioides spores	1	2,982	0	1	0
Gas bacillus	2	513	1	0	1
Malaria	1	1,250	0	1	0
Meningococcus	9	560	5	3[b]	1
Mixed infection, staphylococcus and streptococcus	13	1,691	6	3[a]	4
Mixed infection, miscellaneous *	15	848	7	4[c]	4
Pneumococcus	2	210	2	0	0
Staphylococcus, aureus	56	1,293	34	5[c]	17
albus	10	1,385	5	0	5
unspecified	11	1,915	6	1	4
Streptococcus, hemolyticus	7	895	6	1	0
nonhemolyticus	9[d]	622	5	2[a]	2
unspecified	5	722	2	2[c]	1[e]
Tubercle bacillus	1	120	0	1[a]	0
Vincent's organism	4	90	4	0	0
Totals	149		83	26	40

* Includes combinations of all streptococci, staphylococci, and pneumococci.
[a] One death.
[b] Three deaths.
[c] Two deaths.
[d] Includes eight cases of streptococcus viridans.
[e] Patient reported as improving when death occurred due to glottis oedema.

Vincent's organism were reported as successfully treated. It will be noted that streptococcal, staphylococcal, and mixed infections accounted for the majority (84.6 per cent.) of the cases, with successful results reported in 56.3 per cent. of the cases in this group of gram-positive organisms.

Two hundred and twenty-six cases involving forty-seven different diagnoses indicate that penicillin is being used in the Navy for a considerable variety of conditions, other than Neisserian infection. The diagnoses occurring most frequently are osteomyelitis, cerebrospinal meningitis, soft-tissue abscess, and wound infections. Of all the conditions listed in Table IV, only bronchopneumonia failed to show an encouraging percentage of success with penicillin therapy. Two cases of gas-bacillus infection were reported,—one was successfully treated; the other patient recovered, but the effect of penicillin was not considered to be striking. Of fifty-three cases of soft-tissue abscess, cellulitis, wound infection, and pyoderma (acne and furunculosis) 56.6 per cent. were recorded as successes. There were two deaths in nine cases of septicaemia; five (55.6 per cent.) were considered as successes due to penicillin therapy.

Osteomyelitis. Exactly 50 per cent. of the cases of osteomyelitis showed dramatic improvement with penicillin therapy (Table V). A study of the osteomyelitis case reports substantiates certain observations made by other investigators:

1. Secondary infection of the wound by bacillus pyocyaneus is not influenced by penicillin therapy.

TABLE IV

SUMMARY OF DISEASES (OTHER THAN GONOCOCCAL INFECTIONS) TREATED WITH PENICILLIN AT NAVAL HOSPITALS

Diagnosis	No. of Cases Treated	Average Dosage per Case (*Units in Thousands*)	Results of Treatment		
			Success	Failure	Indeterminable
Abscess	22	1,026	11	4[a]	7
Acne and furunculosis	11	838	7	2	2
Bronchopneumonia	9	705	3	5[a]	1
Cellulitis	6	508	5	1[b]	0
Gas-bacillus infection	2	513	1	0	1
Infection, wound	14	656	7	5[c]	2
Lobar pneumonia	4	1,351	3	0	1
Meningitis, cerebrospinal, acute	14	591	10	3[d]	1
Osteomyelitis	64	1,162	32	3	29
Otitis media	6	763	4	1	1
Peritonitis	9	548	5	4[a]	0
Pleurisy, suppurative	9	1,237	7	0	2
Septicaemia	9	1,411	5	3[a]	1
Sinusitis, acute	6	1,048	5	1	0
Miscellaneous *	41	944	23	10[a]	8
Totals	226		128	42	56

* Includes thirty-three individual diagnoses.
[a] Two deaths.
[b] Patient reported as improving when death occurred due to glottis oedema.
[c] One death.
[d] Three deaths.

2. The presence of a sequestrum, a bone plate, or other foreign material prevents penicillin from sterilizing an infected wound.

3. Adequate surgery must still go hand in hand with chemotherapy of osteomyelitis.

4. Long-standing chronic cases appear to be less amenable to treatment than the early ones.

Syphilis. Preliminary reports by Mahoney indicate that in primary syphilis, penicillin therapy causes rapid reversal of the serological tests and disappearance of the local lesion. A series of cases is now being studied at the Naval Hospital, Bethesda, Maryland. Although the preliminary reports are very promising, the use of penicillin in the treatment of syphilis has not been authorized for general use in the Navy.

THE AVAILABILITY OF PENICILLIN

The commercial producers of penicillin have tremendously expanded their output. As a result, effective February 1, 1944, penicillin is being made available to all ships and shore stations in the Navy in sufficient quantities to fill reasonable needs.

At the present time, a large proportion of the penicillin allotted for Navy use is going to Mobile and Base Hospitals and Hospital Ships in the Pacific combat areas.

Large quantities of penicillin are now being diverted for civilian use in suitable cases. We may look forward to having sufficient quantities available in the near future for all anticipated military and civilian needs.

SUMMARY

The results of the penicillin treatment of 1,976 cases of infectious diseases are reported.

TABLE V

SUMMARY OF CASES OF OSTEOMYELITIS TREATED WITH PENICILLIN AT NAVAL HOSPITALS

Result of Treatment *	Total		Intramuscular		Intravenous		Method Not Specified	
	No.	Per Cent.	No.	Per Cent.	No.	Per Cent.	No.	Per Cent.
Success	32	50.0	14	43.8	8	44.4	10	71.4
Failure	3	4.7	1	3.1	1	5.6	1	7.1
Indeterminable	29	45.3	17	53.1	9	50.0	3	21.4
Total cases	64	100.0	32	50.0	18	28.1	14	21.9

* Average dosage per case treated (units in thousands): intramuscular, 1,400; intravenous, 1,467; and method not specified, 874.

Sulfonamide-resistant gonorrhoea responds dramatically to penicillin therapy,—99 per cent. of 1,750 cases were cured by the treatment.

Diseases due to the streptococcus hemolyticus, staphylococcus aureus, clostridium welchii, pneumococcus, meningococcus, and certain other organisms are also favorably affected, although the results are not so striking as in Neisserian infection.

Fifty per cent. of the cases of osteomyelitis appear to have been cured by a combination of penicillin therapy and surgery. Long-standing, chronic cases, in which there is bone sclerosis with deep-seated, walled-off pockets of infection, appear to be less amenable to treatment than acute cases. Adequate, well-planned surgery is still necessary in osteomyelitis.

Although further study will elucidate many points concerning penicillin therapy, it is impossible to maintain an unenthusiastic attitude toward this powerful new remedy. It has already proved itself as a most valuable addition to the armamentarium of the physician and surgeon.

MARCH FRACTURES OF THE FEMUR *

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In a recent review of the English medical literature [3], only two march fractures of the femur and two of the tibia were found. The inference was that this type of fracture of the long bones is rare.

The author believes that march fractures are not rare, but are reported under many other names,—such as, pseudofracture, insufficiency fracture, *Umbauzone*, wear-and-tear fracture, creeping fracture, exhaustion fracture, insidious fracture, transformation zones, overload injuries, callous tumors, and fractureless callus.

These fractures are the type that occur without an obvious, single, violent trauma, developing insidiously as the result of rhythmically repeated, subthreshold, mechanical insults, which collectively produce structural changes and solution of continuity.

Many cases have been reported in the German literature, the condition being described under various names. Perhaps this type of fracture has been more frequent in Germany because of the strenuous, forced physical training of young people and soldiers for the last ten years in that country.

George Brandt, of Mainz, long ago observed this creeping type of fracture in bone grafts, especially when they had undergone change and had been exposed to increased stress. He also noticed creeping fractures in callus about a healing fracture after plaster casts had been removed.

Henschel called these cases "exhaustion fractures". He described four stages of the pathological process of bone exhaustion:

1. Periosteal neuralgia (stress pain);
2. Ossifying or overload periostitis;
3. Rarefying osteitis (severe exhaustion of bone tissue);
4. Spontaneous fracture of the exhausted bone (exhaustion fracture).

In the first stage there is vague pain, usually diagnosed as of muscle origin. On examination there is muscle stiffness and tenderness, and bone tenderness. Roentgenograms may be negative at first, but should be repeated every ten to fourteen days, when they may show the finest gaps in the trabecular structure.

In the second stage there is circumscribed pain, and there may be pitting oedema over the bone. Roentgenograms reveal periosteal thickening and eventually densities and rarefactions in the bone structure; cracks become progressively wider; and ultimately spindle-shaped callus develops.

INCIDENCE

This type of fracture is most common in the second and third metatarsals, due to the foot going into pronation under fatigue and then letting the weight come on the plantar and medial sides of the metatarsal heads, tending to twist the shafts of the metatarsals dorsolaterally.

The bone affected next in order of frequency is the tibia, usually in the middle third. This fracture occurs most often in infantry recruits and is attributed to the upward swing of the leg, and the resultant backward stress on the supporting leg during rigid marching.

The fibula may be affected in two typical sites:

1. Proximal, a palm's breadth below the head. This lesion occurs usually in gunners, and is due to their jumping back and forth from the gun carriage;

* Presented at the Annual Meeting of the Clinical Orthopaedic Society, Chicago, Illinois, January 24, 1944.

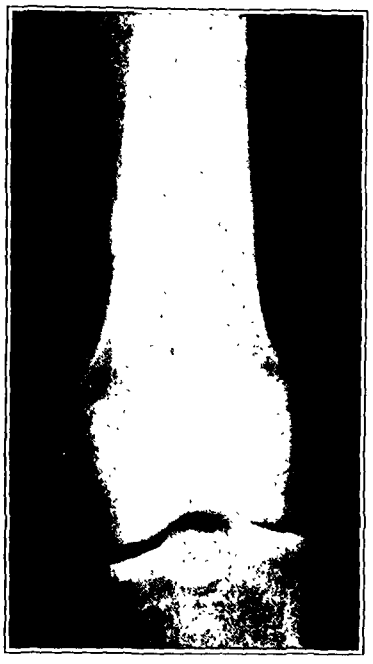

FIG. 1-A

Case 1. March fracture of internal cortex, showing transformation zone across shaft, spindle callus on inner aspect of femoral shaft, and periosteum raised on outer side.

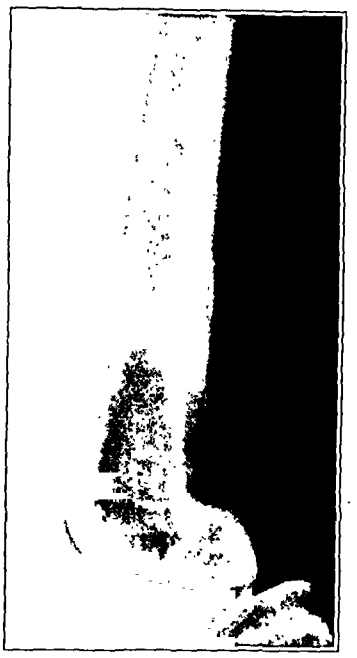

FIG. 1-B

Lateral view of shaft, showing transformation zone and callus on posterior aspect.

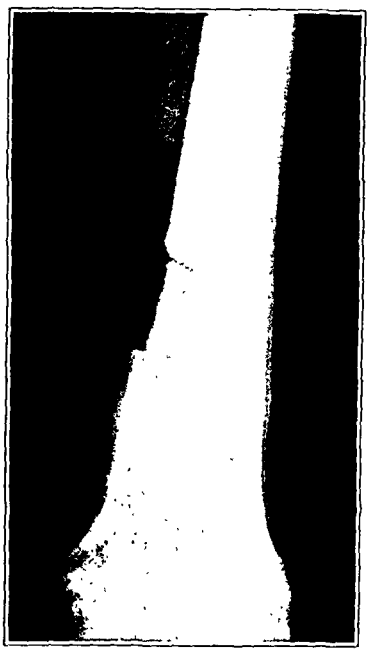

FIG. 1-C

Five weeks later. The march fracture is now clearly visible across the femoral shaft in old transformation zone. The biopsy defect shows above the fracture.

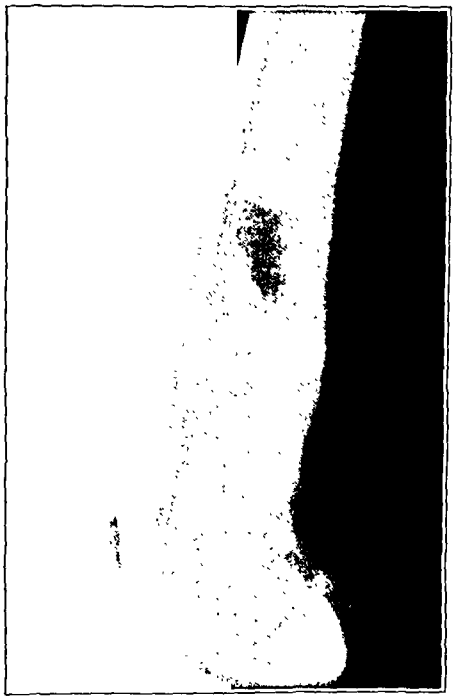

FIG. 1-D

Lateral view taken on same day as Fig. 1-C, showing fracture across entire shaft.

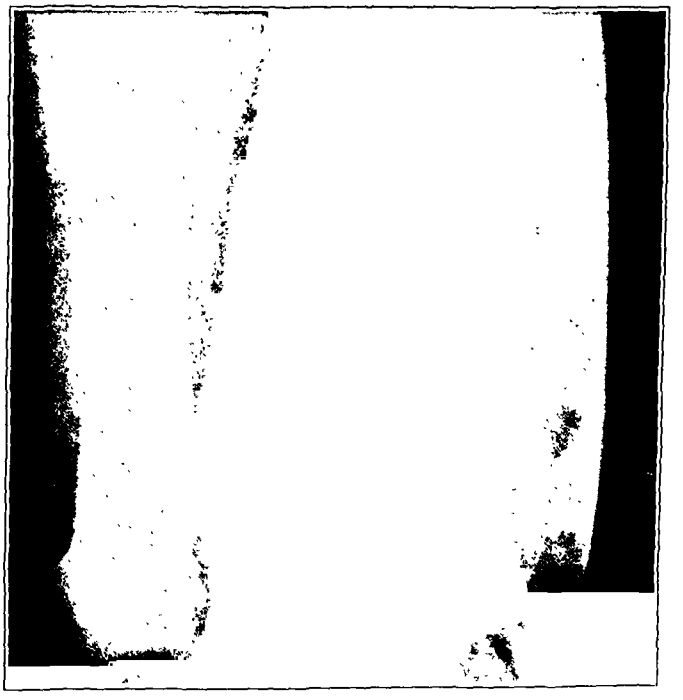

FIG. 1-E

Three months after roentgenograms shown in Figs. 1-C and 1-D. March fracture is healed and the biopsy defect has partially filled in.

2. Distal, just above the external malleolus. This type is commonly found in ice skaters.

Fracture of the femur has been considered most common in the lower third. However, the author feels that the fracture of the neck of the femur is not uncommon, but is often unrecognized. Fractures of the femoral shaft are thought to be due to running in a

crouched position, or to the strain of marching with full packs. Added factors are the rotary mechanism in the hip joint and the traction that the hip muscles exert.

Fractures of the shaft of the humerus have been observed in participants of such sports as discus or javelin throwing. They also occur in hand-grenade throwers.

The os calcis is fractured usually a finger's breadth beyond the subastragalar joint, and is probably due to prolonged marching.

In 1940 Wilhelm described the pelvis as being involved, usually in the pubic rami. This was thought to be the result of antagonistic action of the abductors and adductors of the hip, bringing about a stress on the anterior portion of the pelvic ring during forced walking or marching.

Creeping fractures have been observed in the sesamoid bones, such as the patella.

Recently the author saw a patient with a march or exhaustion fracture of the pars interarticularis between the fourth and fifth lumbar vertebrae.

The author presents one march fracture of the femoral shaft and three cases of march fracture of the neck of the femur, all of which have been treated at the Harmon General Hospital in the last seven months.

CASE REPORTS

CASE 1, a male, aged twenty years, a clerk in civil life, noticed pain in his left knee within a few days after starting drill and athletics in the Army. Two months later, pain was present even when arising in the morning, and numbness of the leg developed on walking. Because of limp and easy fatigability, he was sent to a station hospital. Roentgenograms were taken and revealed an area of sclerosis in the distal third of the left femur with elevation of the periosteum, described as destruction and early "ray" formation. The roentgenographic diagnosis was osteogenic sarcoma of the osteoblastic type. (This diagnosis is not uncommon in cases of march fracture.) The patient was sent to a general hospital for x-ray therapy and amputation. When he arrived there the diagnosis of a march fracture was made, but of necessity he was transferred to another hospital where his case was reviewed, and it was thought advisable to perform a biopsy. A plaster splint was then applied. Before the pathological report was available, it was necessary to transfer the patient to the Harmon General Hospital, where the diagnosis of a march fracture of the lower third of the femoral shaft was made. The plaster was removed; physiotherapy was given to the knee; and he was promptly relieved of all symptoms. The fracture healed, and he was returned to duty.

CASE 2, a male, aged nineteen years, a business-school student in civil life, developed pain in the left hip while on hikes, within seven weeks after entering the Army. The eighth week he started exercises such as

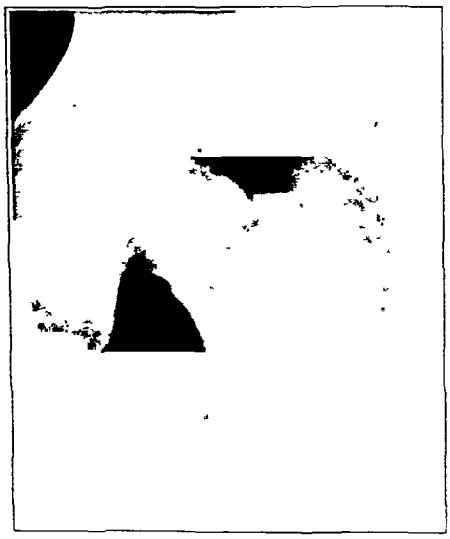

FIG. 2-A

Case 2. March fracture of neck of femur. Roentgenogram taken one week after onset of pain in left hip.

FIG. 2-B

March fracture healed after two and one-half months of plaster fixation.

FIG. 4

Case 4. March fracture of neck of femur after three weeks of basic training. Roentgenogram taken after hip had given way.

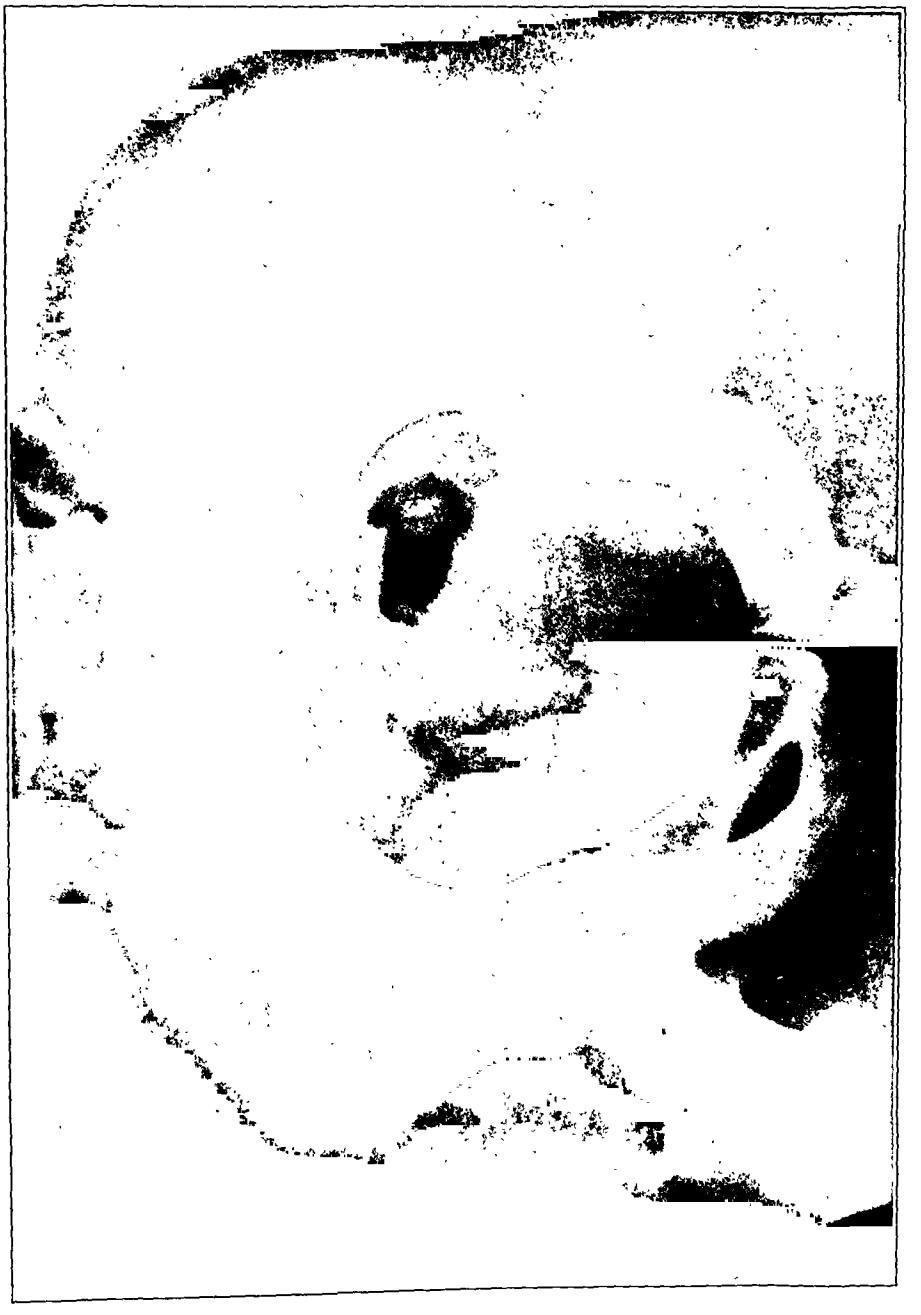

FIG. 3

Case 3. March fracture of neck of femur after hip had given way and patient had fallen. Roentgenogram eleven days previously showed crack in neck of femur which was overlooked at the time.

flexing his trunk back and forth while in a sitting position, with his toes fixed under a rope. The pain in the left hip region increased, but he continued the exercise for an hour. He walked about that evening, rested over Saturday and Sunday, and then resumed full duty. He drilled for one and one-half days, but the hip became so painful that he was sent to Harmon General Hospital. Examination revealed tender adductors, with mild spasm of the left hip muscles. Hip motion was limited only by pain on the inner side. He had been sent to the Hospital with the diagnosis of "obturator nerve injury", and, though the examination suggested a low-grade iliopsoas bursitis, roentgenograms of the hip were taken and revealed a march fracture of the neck of the femur. He was placed in a double hip spica and complete union occurred within three months, after which he was allowed to walk.

CASE 3, a male, twenty-four years of age, a production clerk in civil life, had been in the Army nine weeks when pain developed in the left hip on the drill field. February 14, 1943, he reported to the camp dispensary and was sent to the station hospital for diathermy treatment, with the diagnosis of myalgia. Pain and limp continued. On February 25, 1943, a roentgenogram was taken of the hip: this was negative, and he continued on full duty. On March 8, 1943, he was doing combat training in a swamp, when he stepped up on a log: the left hip "clicked" and he fell. He was taken back to the station hospital and roentgenograms revealed a gross fracture of the neck of the femur with displacement. The roentgenologist then reviewed the films taken on February 25, and reported as follows:

"Irregular transverse fracture of the neck of the left femur, with moderate angulation of the fragments. The patient was seen as an ambulatory case on February 25, 1943, at which time the above fracture was overlooked. The position of the fragments was excellent. There was no separation of the fragments and the patient was able to walk."

The fracture was reduced and the fragments were fixed with a three-flanged nail, on March 22, 1943. The man was transferred to Harmon General Hospital on May 4, 1943. Roentgenograms revealed poor position of the fragments with no union. A high osteotomy of the McMurray type, was done on May 12, 1943. The patient was discharged in October, 1943, with a stable hip, but with a mild swinging limp.

CASE 4, a male, aged thirty-five years, a bookkeeper in civilian life, was inducted on February 16, 1943, and developed a catch in his right hip the first week of basic drilling and hiking. The hip was painful, keeping him awake. The next day the hip muscles were stiff and tender; the pain continued. He reported to the camp dispensary and was given liniment. The second day he went out to the obstacle course for the first time. He crawled on hands and knees for a short distance, and stood up to run through a trench, when his right hip gave way, and he fell. He was unable to walk; so he was taken to the station hospital where roentgenograms were taken and the following report was given:

"March 6, 1943. Right hip: There is observed an ununited fracture of the middle third of the neck of the right femur with overriding of the fragments; marked coxa vara was present. Due to the apparent bone atrophy at site of plane of cleavage, one must consider the possibility of a pathological type of fracture."

On March 15, 1943, the fracture was reduced and the fragments nailed. Traction was used for one month. The patient was then sent to a general hospital, and on September 30, 1943, he was transferred to Harmon General Hospital. By November 8, 1943, there was still no sign of union, so a high intertrochanteric osteotomy was done. He was placed in a hip spica and allowed to get up with crutches in one week.

CONCLUSIONS

1. March fracture is a relatively common type of fracture.
2. This fracture may be expected in almost any bone which has been subjected to strenuous use to which it is not accustomed.
3. Soldiers complaining of symptoms simulating muscle strain, bursitis, *et cetera*, probably should have roentgenograms taken, to rule out this type of fracture.
4. Insufficiency or exhaustion fracture is probably a better term than march fracture.

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3. PETERSON, L. T.: March Fracture of the Femur. Report of a Case. J. Bone and Joint Surg., XXIV, 185, Jan. 1942.
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THE PELVIFEMORAL ANGLE

BY WALTER SALMORE, M.D., NEW YORK, N. Y.

Milch [1] has called attention to the fact that the present method of estimating flexion deformity at the hip is not in the least dependable for scientific purposes. He expressed the opinion that the current clinical test employed "*estimates the total degree of combined hip and pelvic flexion.* In other words, it merely determines the amount of hip extension possible at any given degree of pelvic flexion." In order to obviate this difficulty and to provide a more objective measure for flexion of the hip, the use of a new angle, "the pelvifemoral angle", was suggested.

The pelvifemoral angle has been defined as the backward opening angle formed by the axis of the femoral shaft with Nélaton's line. On the basis of the evidence adduced, it would appear that this angle should be about 50 degrees. In order to determine this value and to test the accuracy and clinical adaptability of the method, 100 hips were measured in accordance with Milch's directions. Normal hips only were measured. Any patient with a history of injury or disease of the femoral head was rejected for the present study.

Further studies are being conducted at the present time to determine the pelvifemoral angle in abnormal conditions involving the hip. Studies made to date, however, indicate the validity of the test, even in cases of transitory limitations of motion.

A child, aged four and one-half years, who had a septic sore throat, had a pelvifemoral angle of 50 degrees on the left side and 68 degrees on the right. It was noted that the patient had marked limitation of hip motion on the right side. Further study of the case revealed a transitory synovitis of the right hip. This case, of course, was not included in the following statistical analysis.

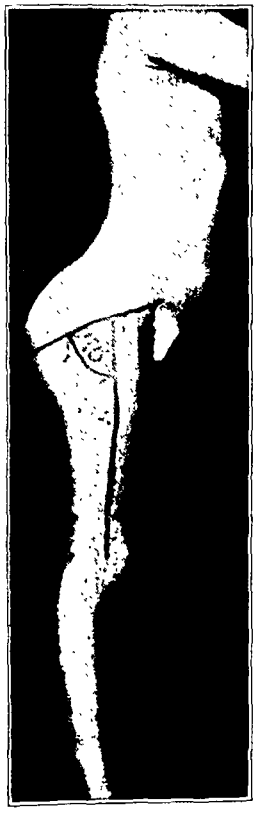

FIG. 1-A

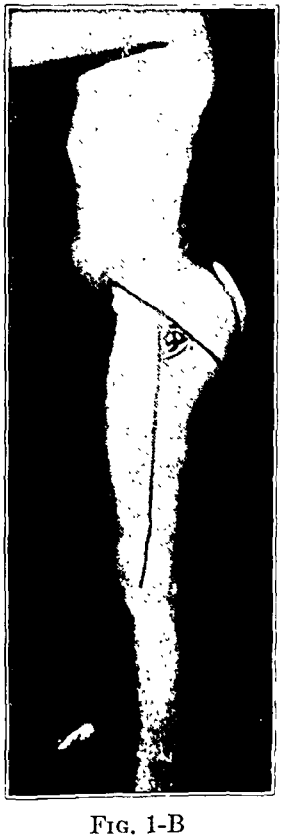

FIG. 1-B

In the erect position, the pelvifemoral angle on the right side measures 70 degrees, and on the left side, 50 degrees. The difference of 20 degrees measures the flexion deformity on the right side. (*Reproduced from The Journal of Bone and Joint Surgery, XXIV, 151, January 1942.*[1]

The cases studied were divided according to age groups and sex (Table I).

In each case both hips were measured, and a record was made of the height and weight of each subject.

The pelvifemoral angle in the first group averaged 58 degrees (ten cases).

The pelvifemoral angle in the remaining (ambulatory) groups averaged 52 degrees (ninety cases). Of these ninety patients, only two had an angle of less than 50 degrees,—one of 47 degrees, and one of 45 degrees. Only four had an angle of 60 degrees or more,—two of 60 degrees, and two of 62 degrees.

In practically all of the remaining cases, the pelvifemoral angle was between 50 and 55 degrees. Height, weight, or sex made no appreciable difference,—a short, stocky female having the same angle as a tall, thin male. There was essentially no difference in the measurement of the normal right hip as compared with the normal left hip.

Early in this work, it was discovered that

TABLE I

Age	*Male*	*Female*
3 to 18 months (Infants in this group were not ambulatory.)	4	6
18 months to 5 years	7	5
5 to 10 years	8	7
10 to 15 years	6	6
16 to 20 years	5	7
21 to 60 years	16	13
over 60 years	6	4
Totals	52	48

more accurate measurements could be made with the patient in the erect position. The reason for this is obvious; while standing erect, the hip is fixed in extension, whereas, a patient lying on his side, generally has a tendency to flex the hip. Since this tendency is more marked in non-ambulatory infants, who naturally cannot be measured in the erect position, it is possible that it may account for the larger pelvifemoral angle noted in the first group. However, all measurements of these infants were determined with the aid of an assistant who was instructed to keep the thigh in full extension.

The determination of the pelvifemoral angle, while a relatively simple procedure, requires care and patience in accurately locating the involved bony landmarks These include the anterior superior spine and tuberosity ischium (connecting these two points gives us Nélaton's line). The latter point is particularly difficult to locate in obese subjects. However, since Nélaton's line passes through the tip of the greater trochanter [2], we have a constant check on the accuracy of our determination After locating the tip of the trochanter on Nélaton's line, the line of the femoral axis, approximately bisecting the lateral surface of the thigh, can be carefully drawn. The angle thus formed and measured by a protractor, as described in Milch's original article, determines the size of the pelvifemoral angle (Fig. 1).

It has been argued that a measurement which requires the location of four anatomical points—each a separate source of possible error—would inevitably produce inaccurate results. To determine the amount of error due to these mechanical difficulties, a number of hips were remeasured. In no case did the difference between the first and second determinations exceed 5 degrees, which may be considered within the limit of clinical error

CONCLUSIONS

1. From this study, it may be stated that the pelvifemoral angle is between 50 and 52 degrees in normal adults and children.

2 In the preambulatory infant, the angle is about 58 degrees.

3 Height, weight, age, and sex make no material difference.

4 The normal left hip has the same angle as the normal right hip

5. The error caused by discrepancies in locating the involved landmarks does not exceed 5 degrees

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THE POSTOSTEOTOMY ANGLE

BY HENRY MILCH, M.D., NEW YORK, N. Y.

First performed in 1826 by Barton, osteotomy at the upper end of the femur was probably the earliest of the operations undertaken with the object of altering the form or function of long bones. Since that time a number of different types of upper femoral osteotomies have been devised to meet specific indications, but that in which the distal fragment is abducted has been given most general recognition. From a technical point of view, the abduction osteotomy presents relatively few hazards, and, with but few exceptions, it might be expected to give an extremely high percentage of successful results. Especially after the bifurcation operation of Lorenz, it is, however, not unusual to observe results which must be considered ineffectual and frequently even distinctly harmful. Viewed in retrospect, it seems probable that these features are to be attributed in large part to misapprehension of certain fundamental facts.

Apart from the slight curvatures which they present, other long bones may be considered as essentially straight. For practical purposes, their mechanical axes are collinear with the shafts or anatomical axes, and they distribute stress in a typical column-like manner. The femur is of an entirely different appearance and has been described classically as being cantilever or craneliko. Because of the medial projection of the neck, it acquires a hockey-stick or triangular outline, with the shaft forming the outer boundary, the neck its base, and the mechanical axis extending from the head to the femoral condyle, its inner boundary. In the erect position, the mechanical axis is collinear with the axis of the leg and with that of the extremity as a whole, but the anatomical axis is displaced laterally and diverges from the mechanical axis by an angle of from 5 to 7 degrees.

The creation of this axial divergence, essential to normal hip function, appears to be the main purpose of the femoral neck. Its present interest lies in the fact that, although osteotomy is performed on the anatomical axis, the desired effect is accomplished through a change in the direction of the mechanical axis. Judged by the eccentricity of its course, the anatomical axis seems to act primarily as an axis of leverage through which the torque of forces about the hip joint may be enhanced. The mechanical axis, on the other hand, is the axis about which progression occurs, so that when parallelism of the limbs is discussed, it is parallelism of the mechanical axes which is intended. Despite its physical non-existence, the mechanical axis is the principal axis of the femur, and appreciation of its importance is prerequisite to an understanding of the abduction osteotomy.

In normal bipedal stance, both legs being of equal length, the pelvis is level and gravitational stress is transmitted equally through the mechanical axes, both of which are perpendicular to their base and parallel to each other. The center of gravity falls between the two axes and the body is maintained in stable equilibrium. In the alternate unipedal stance of normal progression, the center of gravity lies far beyond its single point of support, and the body is obviously in a condition of unstable equilibrium. Physiologically, stability is restored by lateral tilting of the pelvis, so that the center of gravity is shifted outward with respect to the mechanical axis of its supporting limb.

This observation forms the basis of treatment by abduction of pathological hip-joint instability. Since abduction of the limb with respect to the pelvis has the same stabilizing consequence as lateral tilting of the pelvis, it is apparent that stability can be restored through a shifting of the mechanical axis by lateral displacement of the distal fragment following osteotomy. Unfortunately, the fact that stability can be increased by the expedient of such progressive angulation has led to the advocacy of such a high degree of abduction that limitation of motion, frequently painful, is a common sequel. Study of

these unhappy results has yielded ample verification of the general dictum that the mobility of which a joint is capable varies inversely with the stability which it manifests. Beyond this, it has forced the conviction that the angle of abduction is an unreliable determinant of the degree of stability which can be achieved without sacrifice of necessary mobility.

The error involved in using the angle of abduction as the measure of displacement of the mechanical axis arises from the axial divergence previously mentioned. It can be shown without difficulty that, for any given degree of abduction, a variable shifting of the mechanical axis may occur. On the other hand, it can be shown that any predetermined degree of shifting of this axis can be accomplished by varying degrees of abduction [1]. While the angle of abduction is an accurate measure of the change in direction of the anatomical axis, there is no simple formula by which to relate the displacement of the anatomical axis with the desired abduction of the mechanical axis. This is due to the fact that the angular displacement of the latter depends upon at least five factors in addition to the angle of abduction of the osteotomized femur: (1) the level at which the osteotomy is performed, (2) the length of the femoral neck, (3) the angle of the femoral neck, (4) the over-all length of the femur, and (5) the amount by which the osteotomized shaft is displaced upward.

Even an approximate computation of all the factors involved becomes so cumbersome that for practical purposes it must be considered worthless. In this dilemma, a new relationship, which seems to have clinical value, has been defined. This is an angle which has been named the "postosteotomy angle". It is bounded by two lines, one drawn along the inner surface of the femoral shaft; the other, a tangent, drawn from the head to the upper end of the osteotomized shaft. Though this definition may seem somewhat artificial, a closer examination of its connotation will reveal interesting and useful homologies with the commonly recognized structures of normal anatomy.

The anatomical neck is casually described as a flattened process of bone connecting the head and shaft of the normal femur. Its direction is determined by a line, extending through its center from the head to the upper end of the shaft. Essentially the same direction would be indicated by a tangent drawn from the head to the inner aspect of the upper end of the shaft. The angular deviation which might arise from using the tangent, instead of the central axis, would be of such slight degree that it may be disregarded for clinical purposes.

Similarly, in the osteotomized femur, a tangent can be drawn from the upper end of the shaft to the femoral head. Like its analogue, the mechanical axis, it is an imaginary axis and may, therefore, be called the "mechanical neck". It is, however, of real significance in the physiology of osteotomy, and its physical basis lies in the creation of a proximal or neck fragment. This fragment consists of the head, the anatomical neck, and a variable length of the femoral shaft, depending upon the level at which the osteotomy is performed. Because of its L shape, stress transmitted along each of its sides may be considered as acting in the direction of the resultant or diagonal which connects their opposite ends. Where there is no upward displacement of the femoral shaft, as in the Schanz osteotomy, this diagonal may properly be called the mechanical neck of the femur. But where, as in the Lorenz osteotomy, upward displacement is of the essence, the more general description of the mechanical neck as extending from the head to the upper end of the shaft is preferable. From the point of view of the mechanics of the hip joint, the mechanical neck in the osteotomized femur is the exact homologue of the anatomical neck in the normal femur.

The importance of this becomes apparent, when consideration is given to the relationship existing between the angle of the femoral neck and the postosteotomy angle. The angle of the femoral neck, the neck angle of the normal femur, is defined as the angle formed between the anatomical neck and the shaft of the femur. With the slight variation

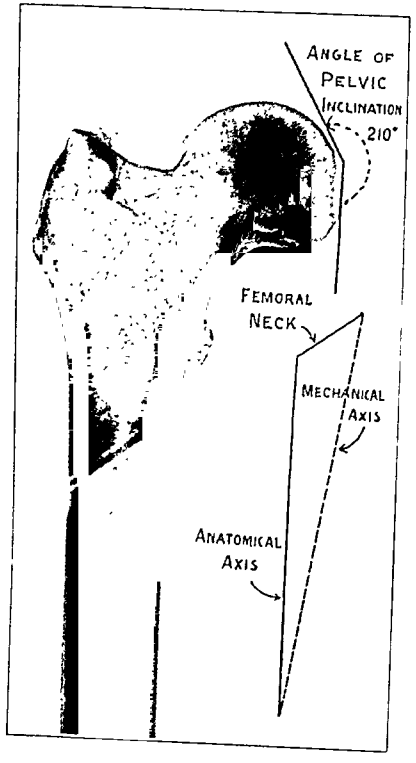

FIG. 1-A

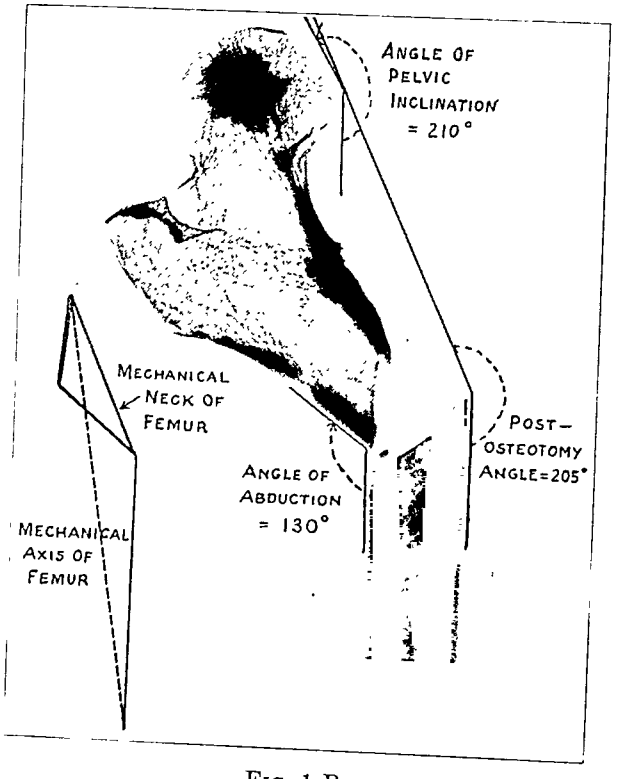

FIG. 1-B

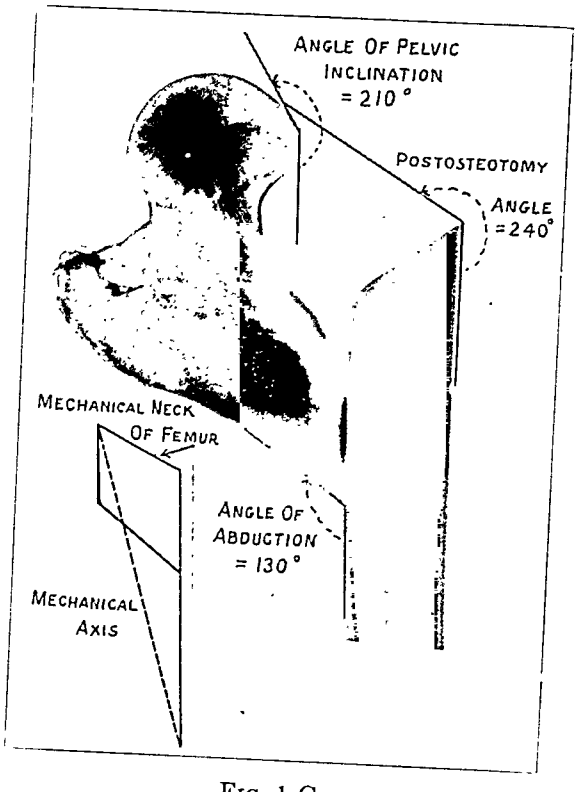

FIG. 1-C

Fig. 1-A: The normal femur. The angle of the neck may be determined, for clinical purposes, by the anatomical axis and a tangent drawn from the head to the upper end of the shaft. The interposition of the neck displaces the anatomical axis laterally, and gives rise to axial divergence between it and the mechanical axis, which lies in the axis of the limb. (*Reproduced from The Journal of Bone and Joint Surgery, XXIII, 592, July 1941.*[2])

Fig. 1-B: The osteotomized femur (Schanz type). The postosteotomy angle is determined "by the anatomical axis and a tangent drawn from the head to the upper end of the shaft". As a consequence of abduction, the axial relationship has been reversed so that the mechanical axis has shifted laterally, or the anatomical axis has shifted medially. (*Reproduced from The Journal of Bone and Joint Surgery, XXIII, 592, July 1941.*[2])

Fig. 1-C: The osteotomized femur (Lorenz type). The length and angle of the neck, as well as the level of the osteotomy, are as in Fig. 1-B. Without changing the angle of abduction, the postosteotomy angle, determined as in Fig. 1-B, has been increased by upward displacement of the shaft. (*Reproduced from The Journal of Bone and Joint Surgery, XXIII, 592, July 1941.*[2])

previously noted, it is, for practical purposes, the angle formed by a "line drawn along the inner surface of the femoral shaft and a tangent drawn from the head to the upper end of the shaft". Except for the omission of the word "osteotomized", this is the identical definition used to describe the postosteotomy angle. By substituting equivalent concepts, it will be seen that the postosteotomy angle, formed between its mechanical neck and the distal portion of the shaft of the femur, must be considered as the neck angle of the osteotomized femur. It thus becomes apparent that, in the osteotomized femur, the postosteotomy angle is the homologue of the angle of the femoral neck in the normal femur (Figs. 1-A, 1-B, and 1-C).

The validity of this observation is further evidenced by the similarity in response of the two angles to the abduction manoeuvre. In the normal femur, the maximum medial displacement of the mechanical axis is noted when the anatomical neck is directed medially at a right angle to the femoral shaft. Outward rotation of the neck at the upper end of the femur would result in an increase in the size of the angle of the femoral neck and a corresponding shifting of the mechanical axis outward, so that ultimately it could be displaced to a position lateral to the anatomical axis. Precisely the same sequence of events is noted in the osteotomized femur, when its neck fragment is adducted, or when its distal fragment is relatively abducted. As abduction increases, the direction of the mechanical neck is reversed and the postosteotomy angle becomes larger, until it opens *outward* instead of *inward*. The apex of the angle tends to point inward instead of outward and, as the mechanical axis moves outward, the anatomical axis moves relatively inward. This reversal in the relationship of the two axes is the direct cause of both the desired improvement in stability and the undesired limitation of motion associated with high degrees of abduction. In this reciprocal relationship, there must obviously be some point which will be optimum with respect to the increasing stability and the decreasing mobility. It is in the determination of a critical value, below which limitation of motion may be avoided, that the surgical significance of the postosteotomy angle appears.

On the anteroposterior roentgenogram of the hip, the ischial tuberosity is seen to be separated from the upper end of the femoral shaft, at the level of the lesser trochanter, by a distance which may be called the *intertuberosity distance* (Fig. 2-A). Since universal motion in three-dimensional space is possible about only a single fulcrum, it is clear that, in the presence of the femoral head or neck, the maintenance of this separation is essential to the preservation of hip mobility. On the other hand, the disappearance of the intertuberosity distance, and the consequent development of a second fulcrum, necessarily result in limitation in at least one arc of the range of motion possible at the hip.

Arising as it does from the divergence between the medially sloping pelvic wall and the laterally sloping femoral neck, the intertuberosity distance affords a convenient indicator of the possibility of motion. Its actual size depends upon the length of the femoral neck, the height of the pelvic wall, and the difference between the angle of the femoral neck and the inclination of the pelvic wall. In any given case, it is, therefore, to be considered as a measure of the incongruence existing between these two angles. In general, decrease in the intertuberosity distance is consequent upon increase in the postosteotomy angle and medial displacement of the anatomical axis (Fig. 2-B). Its disappearance indicates that the point beyond which limitation of motion must occur is the point at which the *angular incongruence* between the neck angle and the wall angle disappears. This takes place at the point where the effective neck becomes parallel to the pelvic wall, with the femoral shaft perpendicular to the interacetabular horizontal line. Thus determined, the critical value of the postosteotomy angle is the angle of tilt of the outer wall of the pelvis.

In the erect position, the actual tilt of the pelvic wall with respect to the base of support can, of course, be varied by tilting the pelvis and the body to one side or the other. Tilting toward the affected limb has the effect of increasing the angle of pelvic wall in-

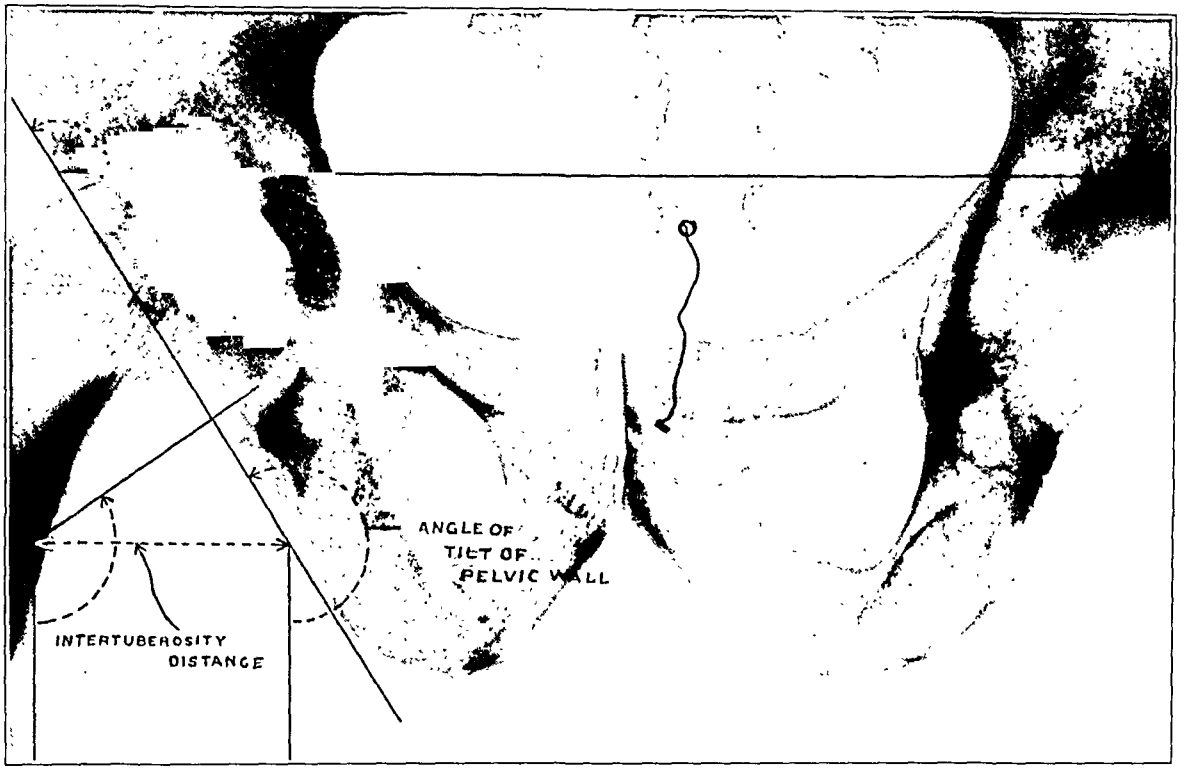

FIG. 2-A

The intertuberosity distance is measured between the tuberosity of the ischium and the upper end of the femur at the level of the lesser trochanter. It serves as a gauge of the angular incongruence existing between the medially inclined pelvic wall and the laterally inclined femoral neck.

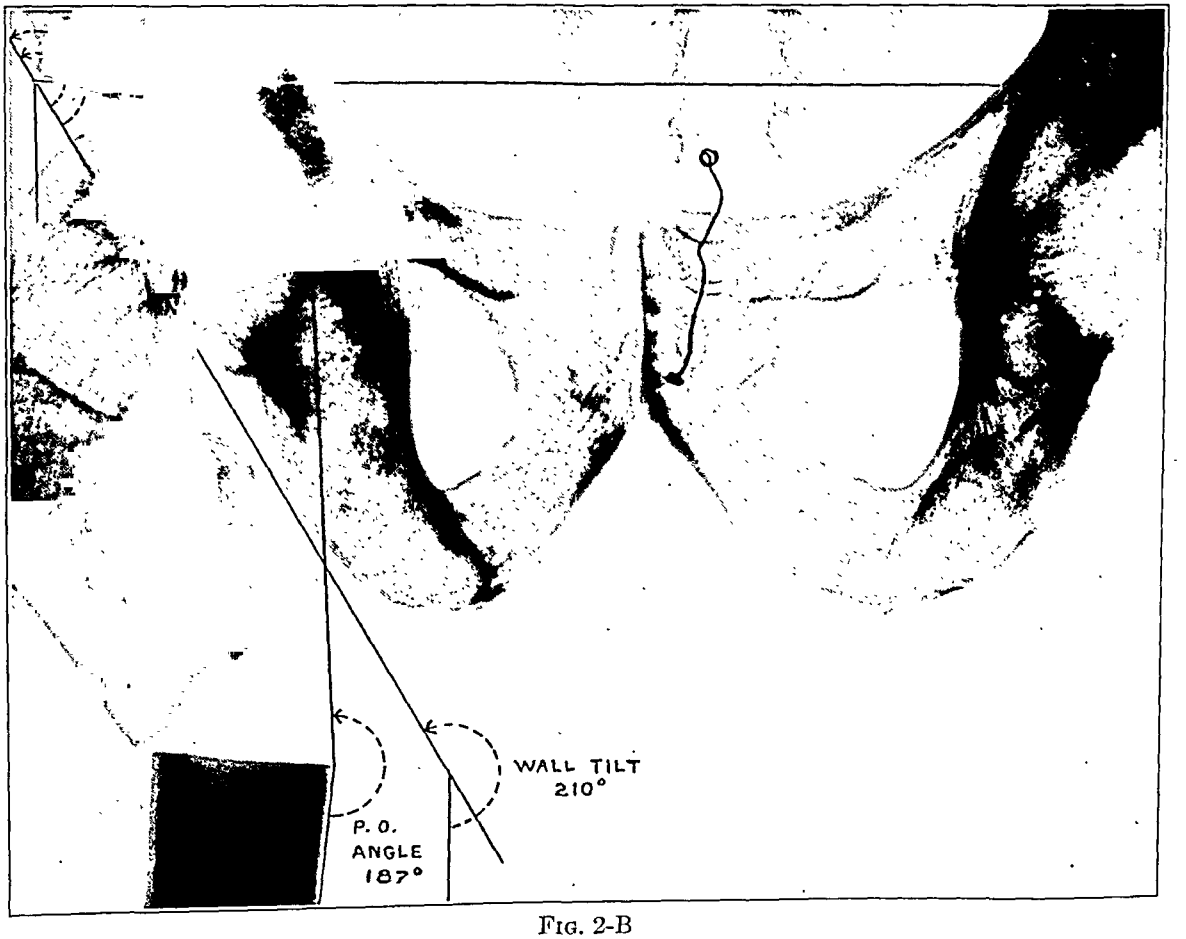

FIG. 2-B

Increase of the postosteotomy angle leads to decrease in the intertuberosity distance. Adduction of the femoral neck, equivalent to relative abduction of the femoral shaft, is the same as external rotation of the effective neck of the osteotomized femur.

clination, and is the equivalent of relative medial displacement of the anatomical axis. Tilting toward the unaffected side naturally has the opposite effect. In the normal seated position, however, such compensatory tilting is not conveniently possible. If, therefore, the postosteotomy angle is made greater than the angle of pelvic tilt of the *level* pelvis, limitation of motion, as in crossing the legs, must be manifested. This value of the wall angle can be determined without any difficulty.

In a relatively normal pelvis, the angle of inclination of the outer wall of the pelvis is a fixed quantity, which can easily be measured against any horizontal line, but preferably from a base drawn through the superior rims of the acetabula. On the right side, this angle, like the neck angle of the femur, is to be measured in a counterclockwise direction; on the left side in a clockwise direction. In order to permit a better comparison with the postosteotomy angle, it has been found desirable to record this angle as measured against a perpendicular to the interacetabular line (Fig. 3). By such measurement, the average angle of pelvic-wall inclination has been found to be between 205 and 210 degrees. This is the critical value beyond which the postosteotomy must not be increased, if the maximum of stability, without limitation of mobility, is desired. In any given case, the postosteotomy angle must never be greater than the wall angle of the pelvis, unless it is specifically desired to limit motion at the hip.

This conception of the postosteotomy angle, and its relation to the angle of pelvic-wall inclination, has proved to be of the utmost value in the analysis of upper femoral osteotomies. Accepting the average of 210 degrees as a critical value, the indications for upper femoral osteotomy may be divided into two main classes: (1) those in which it is desired to increase stability without impairing mobility, and (2) those in which it is desired to limit the range of motion. In the former, the postosteotomy angle must be kept below

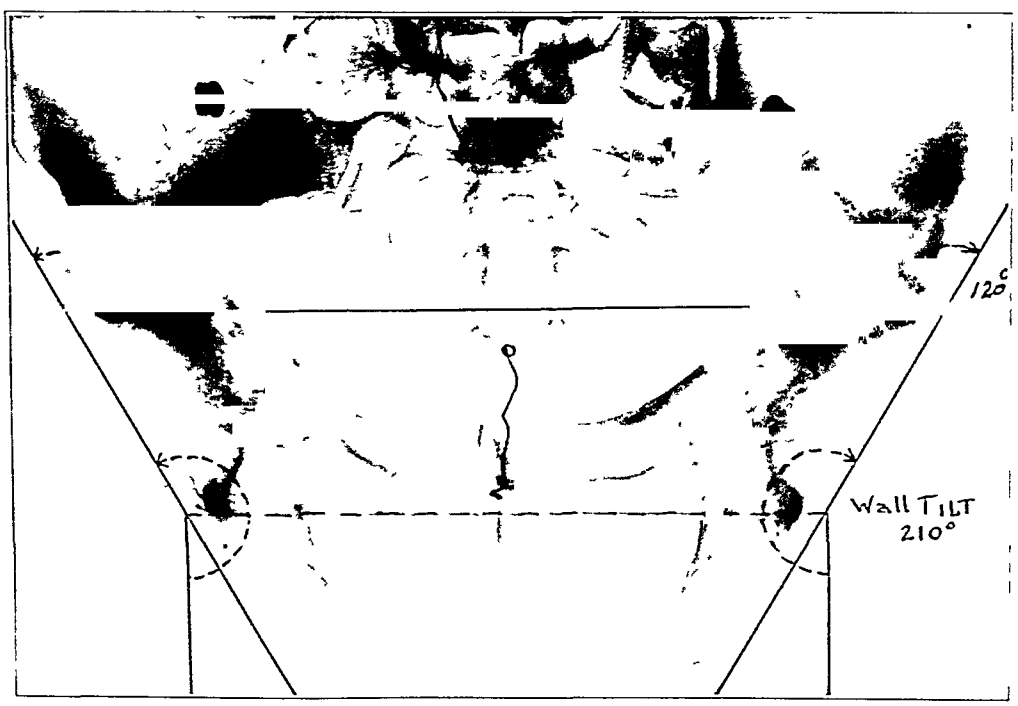

FIG 3

The angle of pelvic tilt may be measured from a horizontal interacetabular line. On the right side, it is measured in a counterclockwise direction, on the left in a clockwise direction. To facilitate comparison with the neck angle of the femur, it is preferable to increase the angle by 90 degrees,—that is, to measure it against a perpendicular to the interacetabular line.

the angle of pelvic-wall inclination; in the latter, the postosteotomy angle must consciously be made greater than the angle of inclination of the pelvic wall.

The indications for the first group are met by the abduction osteotomy as exemplified in the Schanz, Pauwels, McMurrich, and Putti osteotomies. The indications for the second group are satisfied especially by the "pelvic support" or bifurcation type of osteotomy described by Lorenz and von Baeyer. The essential *anatomical* difference between each of these two main groups is to be found, not in the level or the plane at which the osteotomy is performed, but primarily in the size of the postosteotomy angle. The essential *physiological* difference arises from the limitation of motion which is caused by an excessive postosteotomy angle. The particular significance of the *bifurcation operation* is to be found in the fact that, for any given degree of abduction, the postosteotomy angle is considerably greater than after any other type of simple abduction osteotomy, thus, limitation of motion and homolateral tilting can be enforced. The particular merit of the other abduction osteotomies lies in the restoration of stability without necessary limitation of motion.

Clinical experience has abundantly verified these conceptions, and has led to the conclusion that the bifurcation operation appears to be indicated in cases of tuberculous coxitis, where physiological rest and limitation of motion are desired. It is indicated in cases where the head and neck are absent, or where they may be surgically ablated as in the treatment of ankylosis of the hip[3]. It appears to be specifically contra-indicated in congenital dislocations of the hip, fractures of the neck, benign arthritides, and generally in all conditions in which the preservation of motion is desired. In these latter cases, the Schanz or any other type of abduction osteotomy appears to be the operation of choice, provided the postosteotomy angle is kept below its critical value. If, inadvertently or ill-advisedly, undesired limitation of motion should result, it will be observed that, in the unilateral cases, the patient invariably acquires a downward tilting of the pelvis on the affected side. In the bilateral cases, this is manifested by a peculiar, twisting waddle, differing from that seen in congenital dislocations, and characterized by a negative Trendelenburg sign. The waddle is pathognomonic of the alternate, downward tilting of the pelvis on either side. This represents an adaptive mechanism by which the angle of inclination of the pelvic wall is temporarily increased so as to restore the incongruence between the pelvic angle and the postosteotomy angle. The fact that a fixed obliquity of the pelvis may lead to the development of a compensatory scoliosis, indicates the need for treatment and the means to be employed. The postosteotomy angle must be reduced below the critical value of the level pelvic wall. This can be accomplished either by reducing the degree of abduction of the osteotomized fragment, or by resecting the medially projecting apex of the postosteotomy angle.

CONCLUSIONS

The angle of abduction is an unsatisfactory guide in performing an upper femoral osteotomy. The use of the postosteotomy angle is suggested instead. This angle is measured by the line of the shaft and the line running from the upper end of the osteotomized shaft to the femoral neck. The postosteotomy angle represents the angle of the neck of the osteotomized femur. This angle should not be made greater than the angle of inclination of the outer wall of the level pelvis, unless limitation of hip motion is desired. The appreciation of the significance of this angle permits a logical understanding of the indications for the various types of upper femoral osteotomy.

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OPERATIVE REDUCTION OF AN UNUSUAL FRACTURE OF THE UPPER EPIPHYSEAL PLATE OF THE HUMERUS

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From the MacAusland Orthopaedic Clinic, Boston

In the adolescent of about fifteen years of age, a certain type of fracture of the upper epiphyseal plate of the humerus may occur, in which a spicule of the shaft is split off with the humeral head. It is customary to treat such fractures by the routine traction and manipulative methods that are used in treating epiphyseal injuries in this region. Not only is it impossible to effect reduction of this unusual fracture by conservative treatment, but manipulations may result in the production of callus along the humeral shaft, which tends to persist when reduction has finally been accomplished by operative measures.

The writer's interest in this fracture was provoked by seeing three cases within a short space of time, all of which showed essentially the same pathology, and all of which had been subjected to several attempts at manipulative reduction. The conviction that this fracture is reducible only by surgical intervention, and that operative indications should be recognized immediately, led to the making of this report.

OBSTACLES TO CONSERVATIVE TREATMENT

The humerus is fractured along a slanting, irregular plane, so that the upper outer edge of the distal fragment is broader than the lower posterior edge. The broad edge of this fragment protrudes through a buttonhole slit in the capsular extension of the shoulder joint, and the tight grip of the capsule upon this fragment is one of the obstacles to simple reduction. A second obstacle is presented by the long head of the biceps tendon in its position between the fragments. Traction on the arm in any direction only serves to tighten the torn capsule and the tendon into a bowstring that definitely prevents reduc-

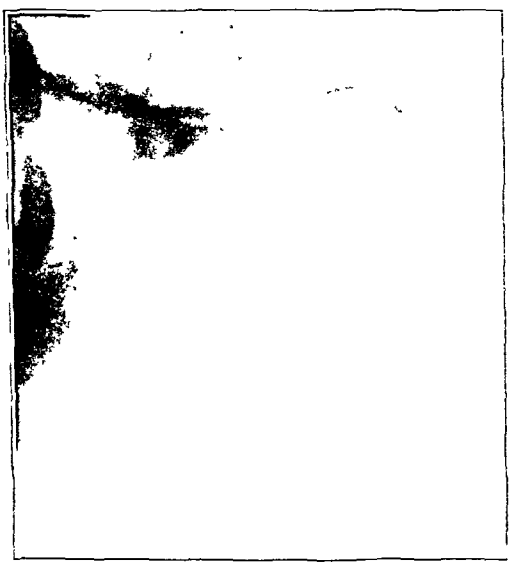

FIG. 1-A

Case 1. D. B. Roentgenogram showing malposition following attempts at manipulative reduction.

FIG. 1-B

Roentgenogram taken after the removal of the plaster spica, showing the screw in place. Note the overgrowth of callus along the humeral shaft.

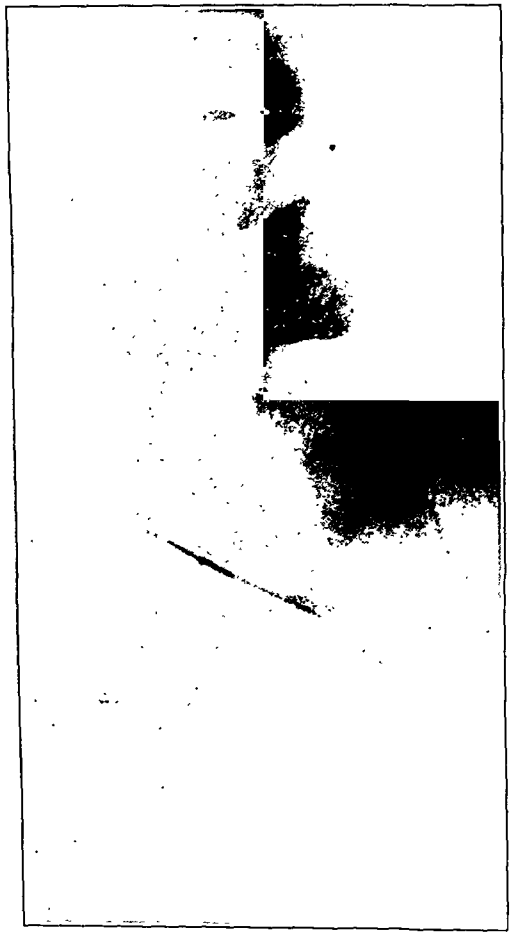

FIG. 2-A

Fig. 2-A: Case 2. E. N. Roentgenogram taken at the time of the injury.

FIG. 2-B

Fig. 2-B: Roentgenogram taken one week after reduction, showing the fragments in alignment and the screw in place.

FIG. 2-C

Fig. 2-C: Roentgenogram taken two years after reduction, showing complete union. Note the overgrowth of callus along the humeral shaft.

tion. In attempts to reduce the fragments by rotation or angulation, the humeral head follows the shaft, because of the tightness of the capsule.

TECHNIQUE OF OPERATION

General anaesthesia is used. An anterolateral incision is made to expose the fracture, care being taken to carry the incision only as far down as is necessary for exposure, in order to avoid damage to the axillary nerve. The deltoid fibers are split and retracted. The shaft of the humerus is found to lie anterior to the proximal fragment and protruding through a buttonhole tear in the capsular extension of the shoulder joint. The shaft is gripped tightly by the capsular fibers. The long head of the biceps tendon lies under the anterior edge of the distal fragment. The proximal fragment lies in the position of outward rotation, and a spicule from the humeral shaft projects from its postero-inferior aspect.

After the removal of the blood clots, reduction is easily accomplished by elevating the taut biceps tendon and prying the shaft gently back through the capsular tear until it lies in alignment with the proximal fragment. A long vitallium screw is inserted through the shaft and the spicule of the proximal fragment. The torn capsular extension is repaired as much as possible. The wound is closed in the routine manner. A plaster spica is applied with the arm in the comfortable position of abduction of 50 degrees. (Such immobilization is indicated, because of the possible overgrowth of callus along the shaft in healing, particularly in cases in which there have been attempts at manipulative reduction.) Fixation is continued for from four to six weeks.

CASE REPORTS

CASE 1. D. B., a male, aged fifteen, injured the left arm while playing football. Roentgenographic examination, made at the hospital to which the patient was admitted, revealed a fracture through the upper epiphyseal line of the humerus, with a spicule of the metaphysis remaining attached to the humeral head. Several attempts were made by the local physician to reduce the fracture by manipulation, and a splint and a plaster spica were applied with the arm in the position of abduction, but these measures were unsuccessful.

On December 12, 1940, one week after the injury, operative reduction was accomplished by the writer. The patient was followed for a period of several months. A roentgenogram (Fig. 1-B), taken two months after the reduction, shows the fragments in excellent alignment and united. Complete function was recovered, and the patient is now (January 1944) attending an Army Air Force School.

CASE 2. E. N., a boy fifteen years of age, sustained a fracture of the upper humeral epiphyseal plate while playing football. A roentgenogram (Fig. 2-A) shows the fracture. Repeated attempts at manipulative reduction were made by the local physician, but without success.

On September 18, 1941, two weeks after the injury, the fracture was reduced by open operation. A postoperative roentgenogram showed perfect alignment of the fragments (Fig. 2-B).

Upon follow-up examination, on January 10, 1944, the result was found to be clinically perfect. A roentgenogram showed complete union (Fig. 2-C). Along the humeral shaft was an overgrowth of callus which had resulted from the manipulative procedures.

FIG. 3

Case 3. F. G. Roentgenogram showing malposition following attempts at manipulative reduction

CASE 3. F. G., a boy aged fifteen, suffered an injury to the arm while playing football. A roentgenogram showed a fracture of the upper epiphyseal plate of the left humerus, with a projecting spicule of bone (Fig. 3). Attempts were made by the local physician to manipulate the fragments into position, but without success.

On October 9, 1939, two weeks after the injury, open reduction was carried out by the writer.

In January 1944, an attempt was made to obtain a follow-up examination. The patient had made a perfect recovery, and was in the Armed Forces. It was not possible to obtain a roentgenogram.

An extensive review of medical literature shows that little has been written regarding this type of fracture, although it is mentioned in textbooks. Similar cases have been reported by Kirmisson, Charry, and Caritat.

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FATIGUE (MARCH) FRACTURE OF THE FEMORAL NECK

BY MAJOR F. C. WATSON AND CAPTAIN E. F. BERKMAN

Medical Corps, Army of the United States

From the Orthopaedic Section, Station Hospital, Camp Lee, Virginia

Fatigue fractures of long bones are being reported frequently from the training camps of our Armed Forces, and are deservedly receiving considerable attention. Failure to recognize early lesions of this type may result in serious disability and deformity. The etiological possibilities of this type of fracture have been discussed by many authors.

We wish to present a case of fatigue or spontaneous fracture of the femoral neck.

E. M., a white soldier, thirty-four years old, began basic training January 1, 1943. On January 9, 1943, on hike, he carried the regulation field pack. While doing double time on a smooth dirt road, he felt a sudden, severe, sharp pain in his right hip. He slowed down to a walk and began to limp; however, he finished the remaining two miles of the hike and also one-half hour of calisthenics before returning to his barracks. Over the week-end he rested, walked to the mess hall and back, a distance of two hundred yards, with a mild limp and slight discomfort in his right hip.

The following Monday, he began the week's activities with an hour of calisthenics, when he experienced slight pain in the right knee, referred along the inner aspect of the thigh. He reported on sick call and was told he needed more exercise. He continued to drill, to hike and do calisthenics, with discomfort, until February 1, 1943, when the pain in the right hip region and knee became unbearable. He was again referred to the Station Hospital for further study.

Upon arrival at the Orthopaedic Clinic, his chief complaints were pain in the right hip and the right knee, and limp while walking. Physical examination revealed a well-developed man, five feet and eleven inches tall, weighing one hundred and eighty pounds, with normal temperature, pulse, and respiration. Examination of the right hip showed mild spasm of the adductor muscles, with a 10-degree limitation of internal and external rotation at the hip joint, a 20-degree limitation of flexion, a 20-degree limitation of abduction, and a 5-degree limitation of adduction. Half an inch of shortening of the right leg was found, but no atrophy of the thigh or calf. Roentgenograms revealed a complete, intracapsular fracture of the femoral neck, adduction type, with impaction of the inferior borders, and associated with a mild degree of coxa vara.

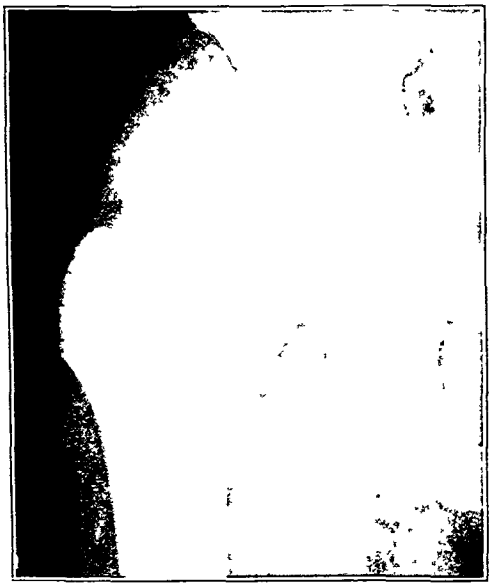

FIG. 1-A

FIG. 1-B

Fig. 1-A: Showing fracture and impaction of the intracapsular neck of the femur.
Fig. 1-B: Result after eight months.

The question arose whether or not the fracture should be disimpacted and nailed, but eventually the patient was placed in bed with a Buck's extension and an eight-pound weight to relieve the muscle spasm. The extension apparatus was removed in two weeks, and the patient was allowed freedom of movement in bed. Heat and massage were given over the entire right leg. Moderate exercise was begun after the second week. At the end of six weeks, the patient was allowed up, with the use of crutches, but with no weight-bearing for four months, after which gradual weight-bearing was allowed. After six months, the patient was allowed to walk with a cane, and experienced no pain or discomfort. A lift on the right shoe corrected the half inch of shortening. Later roentgenograms showed a well-healed fracture with a moderate degree of coxa vara. The patient is now undergoing graded exercises and physiotherapy to prepare him for further duty.

TRANSPORTATION OF PATIENTS WITH FRACTURES OF THE LOWER EXTREMITIES

BY CARLO SAVINI, M.D., F.A.C.S., NEW YORK, N. Y.

About 200 years ago, when the great English surgeon, Percivall Pott, fell and fractured his leg, he absolutely forbade the persons who came to help him to touch and raise him from the ground, but told them to unhinge a door and place it beside him on the floor. Only after he managed to slide onto it without help, did he allow his friends to carry him home.

The author has thought that, if some patients could have been carried to the Hospital on top of a door, as was Pott, they would have arrived in better condition than they did when conveyed with such apparent comfort in a modern and elegant ambulance.

The displacement of the fragments of a fracture is generally due, not to the accident proper, but to the movement of the extremity in preparing the patient for transportation and during transportation. To obtain better results in fractures of the lower limbs, especially of the femur, a simple contrivance has been used in the ambulances of Columbus Hospital, New York City, since 1937. It consists of a wooden board, on which both lower extremities can be secured; so the patient can be carried to the Hospital without suffering any unnecessary movements.

The board is four feet long and fifteen inches wide, and has two canvas straps attached to it at such a distance that one of them can be brought around the pelvis and the other around both legs of the patient and buckled (Fig. 1).

The ambulance surgeons are instructed first to spread a woolen blanket on the board; then to tie both limbs of the patient together, raise the patient *in toto*, and lay him very carefully on the board. The blanket is then wrapped around the body of the patient, and the straps are secured to immobilize his pelvis and both lower extremities (Fig. 2).

In such a position, the board holding the patient is placed on the stretcher of the ambulance and is transported to the Hospital, where, while still lying on the board, he can be examined in the x-ray room as soon as he is admitted to the Hospital, and before he is put to bed. It is only when the patient is placed on top of his bed that the straps holding him are released and the board is removed.

In fractures of the femur, this board has some advantages over the Thomas splint:

First, while the Thomas splint is very useful when applied by a physician, it is not so harmless when applied by a layman. At present, on account of the shortage of interns, the Ambulance Service often is run by orderlies, and the splint may not always be applied properly.

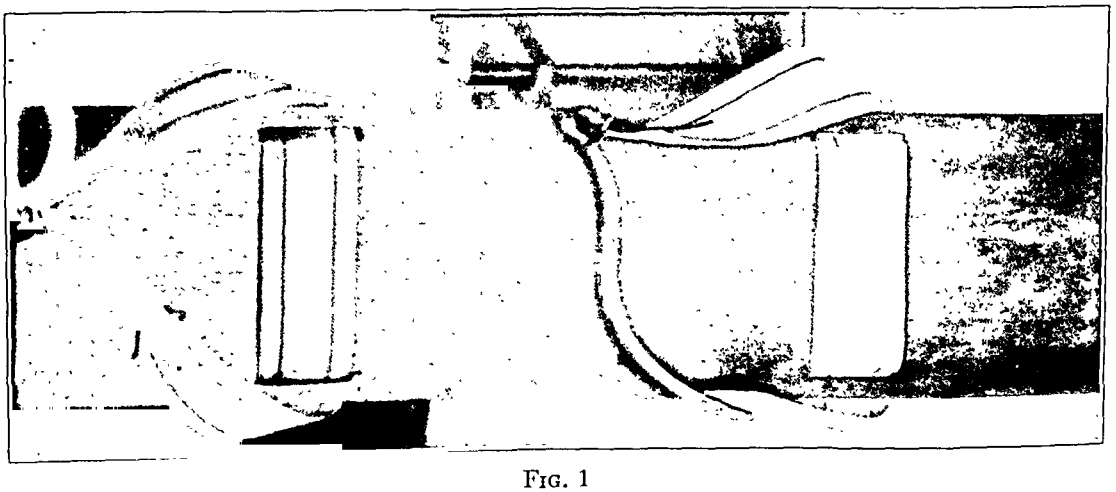

FIG. 1

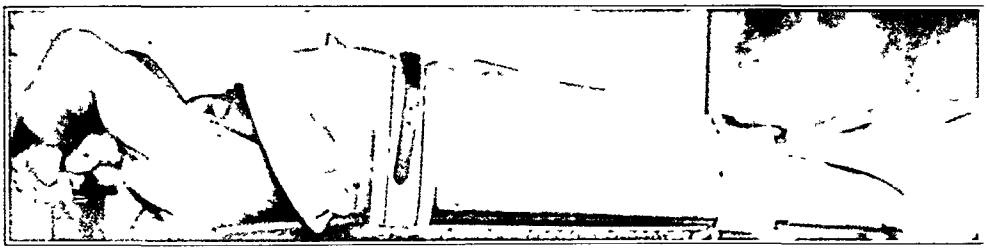

FIG. 2

Second, the board does not require any handling of the affected leg; so the few movements necessary in the application of the Thomas splint are avoided.

Third, the board does not interfere with the roentgenographic examination. This is very important in fractures of the upper part of the femur and of the hip joint. In these cases the ring of the Thomas splint interferes with good vision, so that many times it is necessary to remove the splint in the x-ray room with possible resulting displacement of the fragments.

Fourth, the board is more simple and more rapidly applied.

A RETRIEVER

BY S. J. WOLFERMAN, B.S., M.D., F.A.C.S., FORT SMITH, ARKANSAS

From the Cooper Clinic, Fort Smith

A small dowel for removing a foreign body, a broken instrument, or a screw that has become accidentally embedded in bone tissue during operation has been found very useful by the author. Dr. Warren White, of Greenville, South Carolina, has given it the name "retriever".

This small instrument is two and five-eighths inches in length, and has a center-bore diameter of ten sixty-fourths of an inch, which will fit easily over a screw, nine sixty-fourths of an inch in diameter. It can be used in recovering any of the one-eighth-inch drills. The cutting edge and distal one-eighth of an inch has an additional flare, one sixty-fourth of an inch in diameter, to prevent "grabbing" of the shank on the bone.

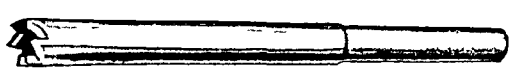

FIG. 1

FIG. 2

By placing the dowel in the drill, and fitting it directly over the tract of the foreign body, or another piece of the same metal as a guide, just enough bone tissue is removed so that the foreign body may be gripped with forceps, may fall into the wound, or may pass up into the cylinder of the dowel.

The same technique may be used in obtaining material for biopsies of bone. When the retriever is drilled into tumor or bone, a certain amount of the bone tissue comes up into the hollow part of the instrument. The author has one retriever with a slit at the side (Fig. 2), so the needle may be put in the side to easily push out the specimen for biopsy study.

THE DEVELOPMENT OF ORTHOPAEDIC SURGERY

A Critical Estimate of the Influence of Three Pioneers—Lewis A. Sayre, Hugh Owen Thomas, and James Knight

BY ROYAL WHITMAN, M.D., NEW YORK, N. Y.

According to Carlyle, "The first duty of Man is to find out what he can do best and keep pegging away at it".

Two notable illustrations of this text are Hugh Owen Thomas and James Knight. The names of these contrasting personalities have been coupled because they were the most important agents in the establishment of orthopaedic surgery, and actually they had much in common.

Both were introduced to their life's work at an early age. Thomas, as his father's assistant, and Knight on his own initiative.

Both were individualists, each "ploughing his own furrow", regardless of professional appraisal. Both adapted their treatment to the natural resources of the body, and were opposed to operative intervention.

Both employed braces, designed and made on their own premises. But here the analogy comes to an end. Knight's supports were applied for the relief of the immediate symptoms; Thomas's to carry out the principle of rest, as the essential factor in the treatment of injury or disease. His contention, that prolonged fixation of a diseased joint was the most effective means of conserving its function, involved him in a bitter controversy with Sayre, who maintained that motion is as essential in retaining the healthy condition about a joint as light is essential in retaining a healthy condition of the eyes, for the ligaments about a joint will become fibrocartilaginous or even osseous if motion is denied them, particularly if a chronic inflammation is going on within the joint with which they are connected.

Sayre was the dominant figure of the period. He was the first professor of orthopaedic surgery, and has been called its forerunner, because he presented it as a branch of surgery free from the traditional restrictions with which the name orthopaedic had always been associated, and which had checked its normal development.

The other members of the group with whom Sayre came into controversial contact could not, from his standpoint, qualify as orthopaedic surgeons. Knight was the exponent of "surgico-mechanics", Davis of "elastic extension", and Taylor of "mechanics and physical culture". Thomas was a general practitioner, who applied the principle of rest on all possible occasions, notably for intestinal obstruction. He was chiefly concerned with what might be called industrial surgery, in which he had been trained by his father, an established bone setter.

Thomas alone among the pioneers could be classed as a scientist, since his conclusions were based upon "observation, experiment and induction", and as such they have held their own. As a leader, however, as contrasted with the flamboyant Sayre, he was lacking in popular appeal, and his methods were practicable only to one of his exceptional capacity and circumstance, as will appear from the following quotations.

"His waiting rooms were packed with patients, mostly drawn from dock yards and work rooms. The equipment of the establishment in Nelson Street is such that no outside aid is needed, no matter from what distance a patient comes. Whether the affection be spinal caries or fractured thigh, he is able to return home in an hour, fitted with a simple and appropriate splint."

A visitor noted, that, in a single morning, Thomas treated 148 patients, incidentally reducing an old dislocation of the shoulder and refracturing two deformed wrists, without an anaesthetic.

Thomas described the appliances that he employed in the treatment of joint diseases in a book published in 1875. They were designed and often fashioned with his own hands to apply effectively the principle of rest, "enforced, uninterrupted and prolonged", and he resented the implication that he was primarily an expert mechanician.

Yet it was his leg brace, introduced by Robert Jones and employed with such success in the first World War, that brought his name into general notice. And Trueta's modification of the Orr treatment for recent war injuries has been a dramatic endorsement of the principle of which he was the chief exponent. Thus his reputation is greater fifty years after his death than during his active life.

This is due to Robert Jones, his devoted disciple, who, supplementing Thomas's practice by operative surgery, made 11 Nelson Street a shrine for visiting Americans. In the history of orthopaedic surgery their names are always linked,—"They were lovely and pleasant in their lives and in their death they are not divided".

Knight, with whose contribution this argument is chiefly concerned, came to New York in 1835, certified in medicine by the Medico-Chirurgical Faculty of Maryland.

Shortly after his arrival, he secured a position as visitor of the Association for Improving the Condition of the Poor. This introduced him to his life's work, for he encountered in his inspections many wage earners who were handicapped by remediable disabilities. The most promising class for relief were the ruptured, and for these he designed an efficient truss. This, he states, served as "an incentive to the construction of appliances for the restoration of impaired powers of locomotion in children laboring under deformities both congenital and the sequelae of infantile paralysis". The expansion of scope continued, and he became a specialist in "surgico-mechanics" which finally included every disability amenable to bandaging and bracing, even hemorrhoids, prolapsus ani, and procidentia uteri.

The most important of the crippling deformities of childhood were those caused by tuberculous disease of the bones and joints, for which effective treatment required the personal supervision only practicable in a hospital. Knight "was deeply impressed with the necessity for such special provision for relief, and made very earnest efforts to accomplish so desirable an object". "Eminent surgeons and citizens recognized the need and gave it the sanction of their names", but, since no material progress was made, he felt constrained "to establish the initiatory efforts in our own dwelling". At this juncture he appealed to the Secretary of the Association of which he was a visitor "who had long had the subject in mind and was surprised and gratified to learn that Knight had made hernia, orthopaedic surgery, and allied maladies a specialty for twenty years". "Thus the chief difficulty in effecting a permanent organization was overcome." In May 1863, Knight, together with his house and equipment, was taken over by the Society, and the Hospital for the Relief of the Ruptured and Crippled came into operation. Its particular purpose, as stated in the certificate of incorporation, is "to supply skillfully constructed Surgico-Mechanical appliances for the Relief and Care of Cripples both adults and children and to make these benefits available to the poorest in the Community". Knight's first annual report was on 828 patients, of whom 334 were children. Of 828 patients, 253 were classed as orthopaedic, and 334 were ruptured. The others formed a heterogeneous group with varicose veins, relaxed abdomen, uterine prolapse, and the like.

There were but fifty admissions to the Hospital, the majority of the cases being "synovitic disease". For these patients his aim was "to restore self sustaining ability by employing every means that may contribute to the strength, vitality and comfort of the patient". He had great faith in tonic medicines, and he was particularly insistent on bodily activity. "No child able to hold up its head is ever kept in bed during the day and all able to walk by pushing a chair in front of them have thus to exercise. . . . For even the most robust constitution would inevitably be weakened and brought to a state of etiolation by long continued repose and in a weak constitution the malady would be proportionally increased."

Knight's enterprise proved so rewarding that within a few years, a large hospital was constructed under his supervision, to which he transported his family, thus preserving the homelike atmosphere of the original.

The hospital might be better described as a home for crippled children. The great majority of the cases were of a chronic character, requiring months or years of residence. Thus "religious and secular instruction was a part of the daily life of the patients". The City furnished the teachers and provided funds for the upkeep of the patients. The treatment was conducted by Knight and a resident assistant. The mechanical appliances were homemade and were supplied to patients free of charge or at a cost price. The hospital was self-contained and self-supporting, carrying out in every particular the designs of its incorporators.

Thus after "pegging away" for many years, Knight had accomplished his purpose, which was a development of the impression made on him by his first appointment and from which he never departed. His book, "Orthopaedia", might seem to be a new development since he states, "the subject matter . . . may be considered as the varied and consolidated experience of many practitioners, modified to our judgement".

This modification however excluded operative intervention, as well as all the advances credited to his colleagues. He rejected Sayre's plaster jacket, because it compressed the chest. He was particularly opposed to Davis's elastic extension, because it impaired the vitality of the limb. He felt so strongly on this point that he was constrained to discharge his resident assistant of thirteen years' standing, because he had described with approval the traction treatment of hip disease, as contrasted with the expectant method "by blisters, poultices and prayer".

Actually very few of the advances of the period to which Knight was opposed have stood the test of time. Davis's elastic extension "which had revolutionized the treatment of bone and joint disease" has been discredited. Of Sayre's numerous contributions to operative and mechanical surgery, only the plaster jacket is now identified with this name. Knight's surgico-mechanics has fared little better. His truss, from which it was evolved, has been discarded, and even the name of his Hospital has been changed to conform to the "adventurous treatment" that he deplored.

Yet, paradoxical as it may seem, Knight, the utilitarian, to whom surgico-mechanics represented therapeutic finality, made unwittingly a more positive and lasting contribution to progress than any of his militant colleagues; for he had controlled the Hospital so absolutely, that on his death it passed to his successors, unhampered by restrictions, academic or otherwise, that might have prevented its natural development. Thus its output in succeeding years has been a determining factor in establishing the status of this branch of surgery and particularly in the development of its most distinctive feature, the operative readjustment of the statics and mechanics of the injured part to restore useful function.

History is concerned with consequences rather than intentions. From this standpoint, Knight, the forgotten man, emerges from obscurity as the purveyor of opportunity, and, as such, is entitled to rank with Sayre, the forerunner, and Thomas, the stabilizer, in a mutually antagonistic triumvirate of pioneers who laid the foundations of orthopaedic surgery.

"He builded better than he knew
The conscious stone to beauty grew."

JOHN JOSEPH NUTT

1870–1943

It was with regret that we learned of the death of Dr. John Joseph Nutt on November 16, 1943, after a very short illness.

John Joseph Nutt was born in Glencoe, Illinois, June 19, 1870, the son of Ann Evans and John Nutt. Through his mother he was a descendant of John Evans, founder of Northwestern University and at one time Governor of Colorado. Following an unusual preliminary education, he attended Northwestern University and, subsequently, Dartmouth University, from which institution he was graduated with the degree of Bachelor of Letters in 1894. In 1897 he was graduated from the Medical School of New York University, and two years later he was given an honorary degree of Doctor of Medicine by Cornell University. After a two-year surgical internship at Bellevue Hospital, he began the practice of orthopaedic surgery which he continued throughout his lifetime.

Dr. Nutt became assistant to Dr. Newton Shaffer, and, following Dr. Shaffer's death, continued as Surgeon-in-Chief of the New York State Reconstruction Hospital at West Haverstraw, New York. He continued to serve that institution for eighteen years, despite the difficulties involved in carrying on his practice in New York City and also extending this service.

At the time of his death he was Orthopaedic Surgeon of the Nyack Hospital, the Willard Parker Hospital, and the Polyclinic Hospital. At the latter institution he had been Professor of Orthopaedic Surgery for many years. He was a member of the University Club and the Dartmouth Club, and belonged to Kane Lodge of the Masonic Order. He was a member of The American Orthopaedic Association, a Fellow of The American Academy of Orthopaedic Surgeons, the New York Academy of Medicine, and The American College of Surgeons, and a member of the American Medical Association and of County and State Societies.

In 1902 he married Blanche Paulson, subsequently deceased. One son by this marriage, Captain John Gordon Nutt, is serving in the United States Army Engineering Corps. In 1938, he married Helen Crane who survives him.

Dr. Nutt contributed many publications to the medical literature, especially on the pathology and mechanics of the foot.

The passing of this kindly, lovable friend is a great loss to those who knew him well.

BEVERIDGE H. MOORE

1881–1944

Our esteemed colleague, Dr. Beveridge Harshaw Moore of Chicago, died on February 29, in his sixty-third year. He had kept at work, in spite of illness, up to the time of his death, taking an active part in the meeting of The American Academy of Orthopaedic Surgeons held in Chicago in January.

Dr. Moore was graduated from Rush Medical College in 1912, and took his internship at the New Haven Hospital. During World War I, he served as Major in Hospital Unit No. 24. He was Associate Professor of Orthopaedic Surgery at Northwestern University Medical School and Chief Surgeon of the Shriners' Hospital for Crippled Children in Chicago. He had been Senior Orthopaedic Surgeon at Loretto Hospital, Consulting Orthopaedic Surgeon at the Illinois Central Hospital, and an attending orthopaedic surgeon at the Chicago Memorial and Cook County Hospitals.

He was a Fellow of The American Academy of Orthopaedic Surgeons and the American College of Surgeons, and a member of The American Orthopaedic Association. He was a member of the Chicago Literary Club, and, at the time of his death, was Acting President of the Chicago Orthopaedic Association.

He contributed to the literature numerous articles on various orthopaedic problems, particularly those pertaining to childhood. He described an original operation for certain types of Erb's paralysis, and was an authority on leg-lengthening operations in which he had a large series of successful results. During the past few years he had been particularly interested in certain congenital anomalies and peripheral-nerve changes. An article by him on this subject appears in the current issue of *The Journal*.

Dr. Moore is survived by his widow and two sons, Edward and Lieutenant Stephen Moore, the latter a paratroop officer.

Those who read his published scientific articles will always remember the high imaginative quality and suggestiveness, the intellectual honesty, and the freshness of style which marked them. All who knew him well will keenly feel his passing.

DAVID EDWIN ROBERTSON

1883–1944

On February 19, 1944, there died in Toronto one of the best beloved of the members of The American Orthopaedic Association. "Eddie" Robertson was a man with a host of friends and admirers. There was that about his charming personality which commended him immediately to all, and, as acquaintance ripened, the sterling qualities of the man became so apparent and so attractive that wherever he was known there were those who delighted to call him "friend".

At the time of his death D. E. Robertson was Surgeon-in-Chief at the Hospital for Sick Children, Toronto, and Assistant Professor of Surgery in the University of Toronto. He was a surgeon of outstanding ability and an important contributor to modern knowledge in the field of the surgery of childhood. His thirty years of service to the children of Ontario have made his name a household word in every town and village in the Province.

Immediately following the completion of his internships and his postgraduate studies in Germany and England, the War of 1914 called him to the colors. He went overseas as Medical Officer of the First Cana-

dian Battalion and with it came through the great gas attack at St. Julien and Langemarck in April, 1915. His letters, written on the field of battle, breathe the spirit of adventure and of devotion to the service. Upon his recall in 1917, he joined Colonel Starr in the organization of the orthopaedic service in the Army, and ultimately succeeded Colonel Starr as Chief Consultant in Orthopaedic Surgery in the Veterans' Hospital. His place in the hearts of the men of the last War was shown by the crowds of old soldiers who swelled the throng at his funeral.

On Easter Sunday, 1936, the world was electrified by the news that this distinguished surgeon, along with two companions, had been buried in the collapse of a mine in Nova Scotia. With this brief newspaper and radio announcement began one of the most dramatic incidents in the annals of mining. Just when all hope that there could be survivors had been abandoned, one of the workmen detected the smell of wood smoke filtering up through the broken rock and sod, and rightly interpreted it as a signal from the entombed men. From then on, the hour-by-hour broadcasts held the breathless attention of the whole of Canada until, at the end of ten days, the devotion of Nova Scotian miners was rewarded by a most dramatic rescue. Those ten days in the black depths of the Moose River Mine brought out in D. E. an exhibition of courage and leadership in the face of forlorn hope that is almost unique in medical annals.

From the effects of this harrowing experience, he made an amazing recovery, but there is no doubt that it took its toll and ultimately contributed to his death.

In 1917, he married Nursing Sister Pauline Ivey, of London, Ontario, whom he had met overseas. Their two sons are in the Armed Forces. Flight Lieutenant Graham Robertson has been in the R.C.A.F. over four years, flying Hurricanes and Spitfires, and Lieutenant Donald Robertson is in the R.C.A.M.C.

D. E. Robertson's high qualities as a surgeon and a teacher have been recognized by his fellows in his election as President of the Academy of Medicine, Toronto, Vice-President of the American Surgical Association, Vice-President of the Royal College of Physicians and Surgeons of Canada, and President of The American Orthopaedic Association. Members of The Association will recall the high level of the clinical portion of the program of the Annual Meeting during his presidency.

He was buried from Convocation Hall, where one of the largest throngs of students, patients, colleagues, and friends gathered to say farewell to one of the bravest and altogether lovable of men.

News Notes

As *The Journal* goes to press, word has been received of the death of Dr. William B. Carrell of Dallas, Texas, on February 23, 1944.

At the meeting of the Executive Committee of **The American Orthopaedic Association** held in Chicago on January 24, 1944, Dr. William A. Rogers was appointed Editor of *The Journal*.

The Executive Board of the **American Public Health Association** announces the Second Wartime Public Health Conference and the Seventy-Third Annual Business Meeting to be held in New York City, October 3, 4, and 5, 1944. Meetings of related organizations will take place on Monday, October 2. Headquarters will be the Hotel Pennsylvania.

The scientific program will be devoted to wartime emergency matters as they affect public health. The Chairman of the Program Committee is Reginald M. Atwater, M.D.

The Sixth National Congress of **Sociedade Brasileira de Ortopedia e Traumatologia** will be held in Porto Alegre, State of Rio Grande do Sul, from July 1 to 4, 1944.

Among the subjects discussed will be the following official reports:

Treatment of Osteomyelitis by Prof. Dr. Mario de Abreu and Dr. Abdias Ferreira.

Treatment of Traumatic Pseudarthrosis by Prof. Dr. Godoy-Moreira and Dr. José Londres.

THE AMERICAN BOARD OF ORTHOPAEDIC SURGERY

Applications from those who expect to take Part I of the examinations must be in the hands of the Secretary, Dr. Guy A. Caldwell, 3503 Prytania Street, New Orleans 15, Louisiana, on or before August 1, 1944. The examinations will be given in New Orleans, New York, Chicago, and San Francisco, during the latter part of September and early October, the exact dates to be announced later. An applicant who has had a rotating internship and at least one year as an Orthopaedic Resident, or has been on an acceptable Orthopaedic Service in the Armed Forces, will be eligible.

THE AMERICAN ORTHOPAEDIC ASSOCIATION

The Fifty-Eighth Annual Meeting of **The American Orthopaedic Association** will be held at Hot Springs, Virginia, June 1 through June 3, 1944, under the presidency of Dr. A. Bruce Gill. Headquarters will be at The Homestead Hotel.

The tentative program as submitted by the Program Committee is as follows:

Thursday, June 1

Morning Session

Healing Time in Fractures of the Tibia and Femur.
Dr. Robert V. Funsten, Charlottesville, Virginia.
Arthrodesis of the Ankle Joint for Old Painful Fractures.
Dr. Halford Hallock, New York, N. Y.
Carpal Scaphoid Fractures.
Dr. Murray Meekison, Vancouver, British Columbia, Canada.
Posterior Approach to the Femur.
Dr. David M. Bosworth, New York, N. Y.
Subtibial Collateral Ligament Bursitis.
Dr. Allen F. Voshell, Baltimore, Maryland.
Surgical Approaches to the Knee Joint.
Dr. Leroy C. Abbott, San Francisco, California.
Discussion will follow each of the above papers.

Noon: Executive Session.

Afternoon Session

Epidemiology of Poliomyelitis.
Dr. John Paul, New Haven, Connecticut. (By invitation.)
Recent Experimental Studies of Poliomyelitis.
Dr. R. Plato Schwartz, Rochester, New York.
Results of Modern Methods of Treatment of Poliomyelitis.
Dr. Robert W. Johnson, Jr., Baltimore, Maryland.
Abstract of Report of Committee Investigating the Kenny Method of Treatment.
Dr. Ralph K. Ghormley, Rochester, Minnesota.
Discussion: Dr. J. Albert Key, St. Louis, Missouri.
Dr. A. Bruce Gill, Philadelphia, Pennsylvania.
Dr. H. Relton McCarroll, St. Louis, Missouri.

Friday, June 2

Morning Session

Bone Sarcoma following Radiation Therapy.
Dr. C. Howard Hatcher, Chicago, Illinois.
Giant-Cell Tumors Treated by Excision and Bone Graft.
Dr. Henry W. Meyerding, Rochester, Minnesota.
Discussion of the two foregoing papers.
Dr. Robert D. Schrock, Omaha, Nebraska.
Dr. Carl E. Badgley, Ann Arbor, Michigan.
Retardation of Length Growth of Bones.
Dr. Sylvan L. Haas, San Francisco, California.

Equalization of Leg Length with Comparison of the Results of Epiphysiodesis and Femoral Shortening.
Dr. Philip D. Wilson, New York, N. Y.
Lt. Col. T. Campbell Thompson, New York, N. Y.
Discussion of the two foregoing papers.
Dr. J. Warren White, Greenville, South Carolina.
Dr. Paul C. Colonna, Philadelphia, Pennsylvania.

Cases of Herniated Nucleus Pulposus.
Dr. Alan DeForest Smith, New York, N. Y.
Dr. Edwin Deery, New York, N. Y. (By invitation.)
Dr. George Hagman, New York, N. Y. (By invitation.)
Discussion: Capt. Joseph S. Barr, Boston, Massachusetts.
Dr. J. Albert Key, St. Louis, Missouri.
Dr. Frank R. Ober, Boston, Massachusetts.

Osteotomy of the Spine.
Dr. M. N. Smith-Petersen, Boston, Massachusetts.
Discussion: Dr. Ralph K. Ghormley, Rochester, Minnesota.
Dr. Frank D. Dickson, Kansas City, Missouri.

President's Address.
Dr. A. Bruce Gill, Philadelphia, Pennsylvania.

Afternoon Session

Program on the general subject of "Minimum Requirements for Bone Grafts".
To be arranged by Dr. Arthur Davis, Erie, Pennsylvania.

SATURDAY, JUNE 3

Morning Session

Front-Line Surgery.
Capt. Bruce Tovee, M.C., Toronto, Canada. (By invitation.)

Amputations.
Lt. Col. R. I. Harris, M.C., Toronto, Canada.

Mechanical and Functional Principles of Prostheses.
Dr. Atha Thomas, Denver, Colorado.

Amputations—Review of Policy and Statistics.
Col. Leonard T. Peterson, M.C., Washington, D. C.

Amputations—Surgery and Plastic Repair.
Lt. Col. T. Campbell Thompson, M.C., New York, N. Y.

Amputations—Prostheses and Fittings.
Col. Francis M. McKeever, M.C., Battle Creek, Michigan.

Discussion and Summary.
Surgeon-General Norman T. Kirk, Washington, D. C.

Noon: Executive Session.

THE AMERICAN ACADEMY OF ORTHOPAEDIC SURGEONS

The Twelfth Annual Convention of **The American Academy of Orthopaedic Surgeons** and the Thirty-First Annual Meeting of the **Clinical Orthopaedic Society** were held at the Palmer House, Chicago, January 23 to 26, 1944.

The fifteen Instructional Courses, given on Sunday and Monday, were an important feature.

The clinical program of the **Clinical Orthopaedic Society** was presented on Monday afternoon, January 24, with the President, Dr. M. O. Henry, presiding. At the Executive Session which followed, the new officers of the Society were elected:

President: Dr. James S. Speed, Memphis, Tennessee.
Vice-President: Dr. Hugh E. Cooper, Peoria, Illinois.
Secretary-Treasurer: Dr. Walter P. Blount, Milwaukee, Wisconsin.

The scientific program of **The American Academy of Orthopaedic Surgeons** was presented on Tuesday and Wednesday, January 25 and 26, under the presidency of Dr. M. N. Smith-Petersen. The complete program was published in the January issue of *The Journal*. At the Annual Dinner, on Tuesday evening, announcement was made of the selection, by the Committee on Scientific Investigation of the Academy, of the Scientific Exhibits meriting awards and certificates:

For *originality of presentation*, the gold medal was awarded to Dr. J. E. M. Thomson, Lincoln, Nebraska, for his exhibit entitled "Local Shock. The Influence of Novocain Sympathetic Block".

For *scientific importance*, the gold medal was awarded to Dr. William Thomas Green, Boston, Massachusetts, for his exhibit entitled "Skeletal Manifestations of Neurofibromatosis".

For *clinical value*, the gold medal was awarded to Colonel John L. Gallagher, M.C., Santa Ana, California, for his exhibit entitled "Compression Therapy Dressings".

The exhibits of the following received honorable mention:

Dr. Lenox D. Baker and Dr. Max P. Rogers, Durham, North Carolina, for their exhibit entitled "Ankylosing Spondylarthritis".

Dr. Eben J. Carey, Dr. Leo Massopust, Dr. Walter Zeit, and Dr. Eugene Haushalter, Milwaukee, Wisconsin, for their exhibit entitled "Experimental Study of Neuromuscular Mechanism".

Dr. Emil D. W. Hauser, Chicago, Illinois, for his exhibit entitled "Low-Back Pain. Rehabilitation of Those Disabled by Low-Back Pain".

Dr. J. Jay Keegan, Dr. Frederic D. Garrett, and Dr. Donald H. Breit, Omaha, Nebraska, for their exhibit entitled "Herniated Intervertebral Disc".

Dr. Clay Ray Murray, New York, N. Y., for his exhibit entitled "Open Reduction and Internal Fixation".

Major Charles J. Sutro, M.C., Fort Riley, Kansas, for his exhibit entitled "Effect of Estrogenic Hormones on the Bones of Partially Paralyzed Limbs of Mice".

At this Meeting no awards were made among the "gadget" exhibits. The Committee feels that in the future, recognition should be made of outstanding exhibits in this excellent group.

Newly elected Fellows presented at the Meeting were:

Dr. Louis Cohen, Schenectady, New York.
Dr. Thomas S. Eddleman, Jackson, Mississippi.
Dr. William Daniel Ewing, Louisville, Kentucky.
Dr. Francis W. Glenn, Miami, Florida.
Dr. James Vernon Luck, Los Angeles, California.
Dr. John H. Moe, Minneapolis, Minnesota.
Dr. Harry Dunlap Morris, New Orleans, Louisiana.
Dr. John A. Murphy, Cleveland, Ohio.
Dr. Francis Garrett Pipkin, Hot Springs, Arkansas.
Dr. Carlo Salvadore Scuderi, Chicago, Illinois.
Dr. Paul W. Shannon, Birmingham, Alabama.
Dr. D. B. Slocum, Eugene, Oregon.
Dr. Luther M. Strayer, Bridgeport, Connecticut.

A number of South American doctors were elected to Corresponding Membership. These are:

Dr. Eduardo Alcivar, Guayaquil, Ecuador.
Dr. José Luis Bado, Montevideo, Uruguay.
Dr. Domingos Define, São Paulo, Brazil.
Dr. Ricardo Detchessarry, Buenos Aires, Argentina.
Dr. Oscar Guzman, Lima, Peru.
Dr. Agustin Inostrosa, Santiago, Chile.
Dr. Mario Jorge, Rio de Janeiro, Brazil.
Dr. L. Barros Lima, Pernambuco, Brazil.
Dr. Oscar R. Maróttoli, Rosario, Argentina.
Dr. Ernesto Prieto, Santiago, Chile.
Dr. Jorge de Romaña, Lima, Peru.
Dr. José Manuel del Sel, Buenos Aires, Argentina.

Executive Sessions of the Academy were held at noon on Tuesday and on Wednesday. At the close of the last Session, President Smith-Petersen introduced the incoming President, Dr. E. Bishop Mumford, and the President-Elect, Dr. Guy W. Leadbetter. The new officers of the Academy are:

President: Dr. E. Bishop Mumford, Indianapolis, Indiana.
President-Elect: Dr. Guy W. Leadbetter, Washington, D. C.
Vice-President: Dr. H. Earle Conwell, Birmingham, Alabama.
Treasurer: Fremont A. Chandler, Chicago, Illinois.
Secretary: Dr. Myron O. Henry, Minneapolis, Minnesota.
Librarian-Historian: Dr. Edward L. Compere, Chicago, Illinois.

The Thirteenth Annual Convention of the Academy will be held at the Palmer House, Chicago, January 21 through 24, 1945.

THE BRITISH ORTHOPAEDIC ASSOCIATION

The Annual Meeting of **The British Orthopaedic Association** was held in London on October 26 and 30, under the presidency of Mr. G. R. Girdlestone, of Oxford, whose address was reported in *The*

Lancet of November 13. It was announced that negotiations between the Royal College of Surgeons and the Association were well advanced, by which it was planned to establish the official headquarters of the Association in the premises of the college at Lincoln's Inn Fields. The advantage to British surgeons of the integration of this and other special branches of surgical science within the domain of the parent body was not the least of the many desirable features of such an arrangement. It was also announced that a joint examining board for orthopaedic nurses had been formed with the Central Council of the Care of Cripples. The joint advisory committee of The Association and the British Empire Rheumatism Council had submitted to the Minister of Health a memorandum dealing with the future services for the treatment of chronic rheumatism and the cooperation envisaged between orthopaedic surgeons and physicians specializing in rheumatic diseases.

Mr. G. Gomme of the Ministry of Labor outlined the development of the Ministry's interim scheme for training and rehabilitation of the disabled, influenced as it had been by the report of the Tomlinson Committee which had been accepted by the Government, the trade unions, and the employers. Some broad conclusions had been reached as the result of two years' work. The arrangements for interviews with disabled workmen while in the hospital, 100,000 of which have been completed, have proved successful. Broadly speaking, physical disability is not as serious a barrier to employment as had previously been thought. Although 70 per cent. of the disabled men interviewed were back at work, it is open to question whether many of the wartime jobs arranged are suitable as permanent occupations. The scheme has not yet been able to cope with that not inconsiderable group, who, for various reasons (usually psychological, but also for general unfitness), are unemployable. It was apparent that the problem of resettlement can be solved far beyond expectations. With the greater information available under the Tomlinson scheme, it was possible to develop a really satisfactory addition to our social services.

Mr. W. Gissane, of Birmingham, described the Birmingham experiment in accident treatment, emphasizing its aim to provide a central hospital with entire control of hospital treatment, together with the other auxiliary services which will achieve complete rehabilitation of the injured workman, either to his pre-accident job or until he is fit to combine his necessary treatment with productive work. For the latter, the man is handed on to "rehabilitation shops", of which it is hoped to provide a series to cover Birmingham. The work of one of these was described in a motion picture. There the hospital surgeon was concerned with planning jobs and progress in movements, power, and duration of work. In the team was also the factory doctor, and the shop manager who was invaluable as an understanding technician in the planning and construction of apparatus and machinery, in taking the training out of the "arty and crafty" sphere so common in the hospital, and in making the work suitable for the more important activity of the factory in which the workman was expected to earn his livelihood. After the treatment in the "rehabilitation shop" has been completed, the man is transferred back to the factory.

Major Frank Stinchfield, M.C., U. S. Army, with a motion picture prepared under the direction of Colonel R. L. Diveley, described the methods employed in the United States Army for the rehabilitation of the sick or injured soldier. The motion picture illustrated the work of a special reconditioning center established in Great Britain, the purpose of which is physical and mental re-education and training through gymnastics, physiotherapy, sports, and field work.

Major Ralph Soto-Hall, M.C., U. S. Army, discussed "Lesions of the Articular Cartilage of the Patella", which were found to have a high incidence scarcely noted in the Anglo-American literature. Fractures in the cartilage of the patella without bone involvement are common, and a delayed manifestation is chondromalacia patellae. This was believed to be a form of aseptic necrosis and appeared as degeneration of the cartilage matrix. Many patients have little disability if the area is small. Partial resection of abnormal cartilage was useful only in small lesions. Total resection of the articular surface was not satisfactory. Patellectomy gave good results; Major Soto-Hall used it in five cases, four with good or excellent results, and one with no improvement. In patellectomy, care must be taken to restore proper tension in the expansion of the quadriceps muscle by overlapping the tendon.

Major R. A. Patterson, M.C., U. S. Army, reported that in "Fractures of the Upper End of the Tibia involving the Knee Joint" excellent results can be obtained by conservative methods, such as, aspiration of hemarthrosis, reduction by compression or manipulation, and the institution of early motion (passively the day after and actively about five days after the reduction), the limb being in a Thomas splint with a Pearson attachment and traction applied. The improved control obtained by the incorporation of the patient's thigh and the upper part of the splint in plaster-of-Paris was among the points demonstrated in a motion picture. Major Patterson emphasized that in the Army one must use a treatment available to all surgeons, and one that will return a man to duty in the shortest time.

Wing-Commander W. D. Coltart, Royal Air Force, reviewed a series of "Injuries of the Astragalus", which were to be regarded as having an incidence peculiar to the crashes of air-crews. He urged the importance of complete reduction of the subastragalar dislocation or subluxation which occurs in so many fractures of the neck of the talus. It is secured by plantar flexion, but the displacement may recur when this position is relieved at the end of the first month. Posterior dislocation of the body is a surgical emergency, and it is of the utmost importance to reduce it at once. The body should be preserved when possible, even when in

late cases avascular necrosis is present, for arthrodesis will give better results than astragalectomy, keeping intact the height of the foot and the leverage of the forefoot. If the whole bone or the body is irretrievable, a second-stage fusion of the tibia to the os calcis is to be preferred to astragalectomy. While deformity of the body following avascular necrosis rendered fusion inevitable, it had to be remembered that mere radiographic opacity without deformity could resolve, if immobilization of the contiguous joints had been begun before opacity appeared and was continued long enough (as much as thirty-seven weeks) for regeneration to occur.

Mr. St. J. D. Buxton, of London, discussed "Gunshot Wounds of the Elbow Joint". His record of fifty-one wounds involving the elbow joint were collected from the Middle East Forces after the third Libyan campaign in the summer of 1942. The operation carried out in the forward areas was simply excision of skin edges and necrotic tissue, removal of loose pieces of bone, control of bleeding, dusting with sulfanilamide, the insertion of a soft paraffin-gauze pack, and the placing of the limb in plaster-of-Paris from the axilla to the metacarpal necks. Suppurative arthritis developed in thirty-one of the fifty-one patients, and non-suppurative arthritis in the remaining twenty. Nerve injury was seen in fourteen cases. The high recovery rate of ulnar-nerve injuries, which complicated fractures of the olecranon, was attributed to skilful primary surgery and the placing of the elbow at a right angle during the period of acute inflammation.

Mr. R. Watson-Jones, of Liverpool, described his recent journey with other surgeons to Russia, telling of the life, work, and recreation in this war-stricken country, of the plodding workers, the courage of the soldiers, both men and women, the resourcefulness and energy of the doctors and nurses, and of the frightful difficulties so successfully overcome. A journey to the front lines took the visitors through a pleasant, fertile countryside, surrounding many blasted and ruined cities, to tented hospitals, and to wooden hospitals in the midst of pine forests, constructed during quiet periods by the nurses themselves. They were impressed by the skilful organization of casualty reception and clearance to well-equipped wards, in many of which beds were arranged in tiers. Present-day Russian medical service is a remarkable achievement. Twenty-five years ago there were only thirteen medical faculties; now the aim is to graduate 25,000 doctors a year.

Professor H. J. Seddon, of Oxford, gave an account of a recent epidemic of "Poliomyelitis in Malta". In the second half of 1942, affairs in Malta reached a crisis. Not only had the island been subjected to the most devastating bombing but there was such a shortage of food that the population, both civil and military, were feeling the effects seriously. In the middle of November, there was an outbreak of poliomyelitis, beginning in the civilian population and affecting some 400 persons, mostly children under five. Two weeks later, there was an outbreak among Service personnel, with a total of sixty cases. Investigation showed that the virus was almost certainly a native one. There was practically complete immunity of the adult Maltese population, and a comparative absence of immunity among non-native troops. The mortality among the troops was nearly five times that among civilians. There was no convincing evidence that overcrowding had anything to do with the epidemic. Indeed, overcrowding had passed its peak, and the number of contact cases was remarkably small. Malnutrition could not be blamed either, for, in the neighboring island of Gozo, where the food supply was almost normal throughout, the incidence of the disease was much the same as in the main island. Owing to the great shortage of fertilizers, permission had been given in July to use raw sewage on farms. This measure was followed by an outbreak of typhoid fever, *before* the crops being fertilized had been gathered. The devastation in the densely populated parts of the island encouraged the breeding of flies, and it is possible that the typhoid was fly-borne. The epidemic of poliomyelitis may also have been spread in the same way, but it is also possible that it had come from contamination of the water supply with sewage. The chlorination, which was adequate for controlling contamination of the water with organisms of the enteric group, was inadequate for destroying the virus. Unfortunately, it was not possible to carry out any inoculation experiments, and the presence of the virus in the water supply is conjectural. In the majority of cases, the lumbar and sacral segments of the cord were much more severely affected than were other levels, and there is little doubt that the portal of entry was mainly alimentary.

At this meeting, Colonel Rexford L. Diveley, M.C., U. S. Army, was elected Honorary Member of The British Orthopaedic Association.

New Associate Members elected to the Association at the same meeting include the following:

Mr. E. T. Bailey, London.
Capt. J. G. Bickerton, Kendal, Westmorland.
Major A. C. Brewer, Liverpool.
Major J. Charnley, Bury, Lancashire.
Mr. J. S. Ellis, Bramley, Basingstoke.
Capt. H. R. W. Lunt, Bampton, Oxfordshire.
Major R. J. B. McEwen, Moreton, Cheshire.
Mr. J. A. McLauchlan, London.
Lt. Col. G. A. G. Mitchell, Aberdeen, Scotland.
Mr. A. R. Parkes, Glasgow, Scotland.
Major F. B. Thomas, Swansea, Wales.

Current Literature

PAIN. PROCEEDINGS OF THE ASSOCIATION FOR RESEARCH IN NERVOUS AND MENTAL DISEASE. (Held in New York, December 18 and 19, 1942). Vol. XXIII. Baltimore, Williams & Wilkins Company, 1943. $7.50.

In this book, an attempt is made to bring together the most recent experimental and clinical data and viewpoints regarding pain. In the beginning, it is emphasized that the study of pain requires a separation of perception of pain from reaction to pain. The pain threshold in man is relatively uniform and stable under studied conditions. A normal pain threshold may be found in persons with serious damage to the nervous system, also in those with profound disturbances in personality function. Elevation of threshold can occur from damage to the nervous system, from an analgesic agent, or from a conviction on the part of the patient that pain sensation has been impaired. Inflammation of the skin lowers its pain threshold; otherwise lowered pain threshold has been found only with hysteria and malingering.

The unit in the peripheral sensory receptive mechanism for pain is not a spot innervated by a particular nerve fiber, but is an area of terminal distribution of a unit neuron of variable extent, of much more than spot dimensions, which can be measured in square millimeters or centimeters. This terminal constitutes the neurosensory unit. Pain impulses are carried in both myelinated and unmyelinated nerve fibers. Conduction in the unmedullated C fibers is one to two meters per second, and in the medullated A fibers fifteen to ninety meters per second.

In a discussion of the central representation for pain, the spinothalamic tracts are not the only carriers of pain impulses to the higher centers, the spinotectal tracts being concerned in this function.

There are three levels of integration of pain: the highest is the cerebral cortex at the postcentral convolution. Integration here produces the normal appreciation of pain. The pain of a phantom limb appears to be, at least to some extent, upon the basis of a hypersensitive receptive mechanism, probably at the cortical level. This condition has been relieved by appropriate cortical ablation. The second level of integration of pain is the thalamus. The function of the thalamus is not so much the appreciation of pain, however, as its integration with other sensory modalities. The third and lowest level of pain is the tectum mesencephali. This is the center where pain in primitive life was perceived, but which, in normal man, rarely functions in that capacity, its powers being taken over by the thalamus and the cortex. Superficial sensibilities are represented bilaterally in both the thalamus and the cortex. Therefore, in some cases of intolerable monomelalgia, a bilateral chordotomy may be necessary to relieve the pain.

Experiments carried out to determine whether there is a tendency for visceral response to be localized to a stimulated area showed absence of local signs. This fits in with the general reactions of the autonomic nervous system,—namely, that the afferent impulse goes to the cortex, whence it is relayed to the hypothalamus, and then is followed by a generalized sympathetic discharge.

The chapter in summary of headache mechanisms includes headache and brain tumor, headache from changes in intracranial pressure, from histamine, migraine, fever, and hypertension. Then follow several chapters on pathways of pain from disease in various regions,—such as, the nasal and paranasal areas, the eye, the scalp and neck muscle, the joints, the urinary tract, the pleura and pericardium, the bronchi and lungs, the digestive tract, and the heart. Experiments were carried out, showing that severe pain in the arm or head affects the heart and alters the T waves in the electrocardiogram. These studies were carried out chiefly in individuals with heart disease, in whom the electrocardiogram is naturally more susceptible to change than in normal patients.

Another chapter is given to a discussion of pain causing a decrease in renal function. There is an excellent chapter on the sensory innervation of the viscera, based on neurosurgical procedures for the relief of intractable pain. Three chapters are given to an evaluation of different procedures for the relief of pain, one of them on posterior rhizotomy with a statement of its value and limitations. The place of nerve or tract section for relief of facial pain is considered. The writer feels that partial or complete section of the root of the fifth nerve, or the anterior divisions of this nerve, intracranially by the temporal route, is the method of choice for the relief of facial pain. Medullary tractotomy may be used in certain selected cases, but is not suitable for routine use.

There is finally a chapter on the use of high cervical chordotomy for relief of pain. The writer feels that this is a better operation and a safer one than medullary tractotomy. A brief discussion of section of the pain fibers in the mesencephalon follows.

This book carries the weight of authority and should appeal, not only to neurosurgeons and neurologists, but to men who are interested in the problem of relief of pain in other fields,—such as, otolaryngology, ophthalmology, orthopaedic surgery, cardiology, and, indeed, general medicine.

Tratamiento de las Fracturas del Cuello del Fémur. José Valls y Enrique Lagomarsino. Buenos Aires, El Ateneo, 1943.

An unusually attractive volume is the book on Treatment of Fractures of the Neck of the Femur by these two distinguished surgeons of Buenos Aires, which is dedicated to their teacher, the late Vittorio Putti of Bologna. The book is beautifully illustrated with reproductions of roentgenograms, photomicrographs, excellent drawings and photographs of operative techniques, and color plates showing the circulation of the head.

The authors speak of the successful treatment of these fractures as one of the conquests of modern surgery.

Following the classification of the various types of fractures, fifty pages are devoted to the physiopathology of fracture of the anatomical neck, the "medial fracture". The chapter on Treatment gives a brief résumé of the steps in the development of modern methods of treatment of these fractures. Special recognition is given to Whitman and Smith-Petersen for their contributions to the evolution of the treatment of fractures of the femoral neck.

Believing that "in principle all medial fractures of the neck of the femur should be operated upon", the authors point out the few exceptions to this rule and then, in considerable detail, discuss the preoperative treatment and the various operative procedures.

The results in their series of cases (bony union in 82 per cent. and perfect function in 65.5 per cent.) are compared with results reported by other operators in various articles.

The chapter on the causes of failure of osteosynthesis is especially interesting, because of the frank discussion of individual cases and the excellent illustrations.

One chapter is devoted to the osteosynthesis with the "stud bolt", first described by Putti, and later modified by Godoy-Moreira and others. Illustrated cases treated by this method are included.

Aseptic necrosis of the head is discussed at length with references to many other authorities. Case reports with unusual pathological specimens and roentgenograms add to the value of this chapter.

"Lateral" fractures (at base of neck and of trochanter) are also considered and a section in the appendix is devoted to various types of osteotomy. A full bibliography adds to the authoritativeness of the references throughout the book, and is another evidence of the authors' familiarity with the literature of many countries and languages.

The book is a valuable one for men doing this type of surgery, whether or not they read Spanish easily.

Fractures and Joint Injuries (In Two Volumes). R. Watson-Jones, B.Sc., M.Ch.Orth., F.R.C.S. Ed. 3. Baltimore, Williams and Wilkins Company, 1943. $18.00.

The third edition of this excellent textbook by R. Watson-Jones, 923 pages in length, has been written in the author's own words, "after the experience of war", and reflects its broadening influence. The first edition was written under the threat of war, and the second with the realization of war. As the author says, the experience in the Royal Air Force Medical Service has been greater than that of a lifetime of civilian practice. Many of the lessons from these strenuous years of war surgery have found their way into the revision of this work. Scarcely a page has been left untouched.

The chapter on "Open and Infected Fractures and War Wounds" has been enlarged. It is beautifully illustrated, as is every other chapter, with diagrams, photographs, and particularly with color plates, which add much to the clarity and understanding of the techniques described.

New sections have been added on sequestrectomy, vascular injuries, immersion foot and shelter foot, traumatic oedema, and the crush syndrome, gangrene due to tourniquets, Volkmann's ischaemic contracture, traumatic asphyxia and chest injuries, avascular necrosis of the hip, joint distraction of fractures, roentgenographic diagnosis of union, internal fixation of fractures, "no-touch" technique, treatment by onlay grafting, burns, contractures of the hand, and other injuries.

Of special interest is the new chapter on "Rehabilitation". The heartwarming results obtained by psychological and varied physical training, in restoring confidence to men's minds and function to injured bodies, are sufficient recommendation for continued development in this branch of surgery.

The entire work is enriched by the author's fresh and enthusiastic viewpoint, and deserves a prominent place on the surgeon's reference shelf.

Libro de Oro. Dedicado al Professor Dr. Alberto Baraldi, 1915–1940. (The Golden Book. Dedicated to Prof. Dr. Alberto Baraldi on the Twenty-Fifth Anniversary of His Surgical Career.) By his colleagues and students. Rosario, Argentina, Emilio Fenner, 1940.

This is an anniversary volume of 350 pages containing twenty separate contributions by the colleagues and former students of Prof. Baraldi. The topics covered are mainly of general surgical interest and include such subjects as cerebral ventriculography, pathological anatomy of breast lesions, retroflexion of the uterus, and three articles of special interest to orthopaedic surgeons, which are reviewed as follows:

FRACTURA-LUXACIÓN DE LA ARTICULACIÓN DE LISFRANC (Fracture-Dislocation at Lisfranc's Articulation). Luis A. Introini. p. 113.

According to the author's studies only a little more than 200 cases of this type of fracture-dislocation have appeared in the world's literature. Dislocations have been classified according to the relative displacements of the first and the outer four metatarsals. If only one or the other of these two parts of the forefoot is dislocated, the lesion is called partial; if both are dislocated, the lesion is total. In the total lesions, both parts may be dislocated in the same direction (homolateral), or in opposite directions (heterolateral).

In the chronic cases—more than three weeks old—operation is often unavoidable. In the acute cases, either open surgical or manipulative methods under complete anaesthesia may be employed.

The author reports a single case of heterolateral fracture-dislocation, with fracture of the base of the fifth metatarsal, treated by closed reduction and immobilization in plaster.

SINOVITIS SECA DE LOS JUNTADORES DE MAÍZ (Dry Synovitis of Corn Huskers). Fernando Noguerol Armengol. p. 163.

The author describes this condition as being typical of corn huskers. It involves particularly the left arm, which becomes swollen, red, and tender. A localized area of tenderness is to be noted in the anatomical snuff box, and any motion involving the extensors of the thumb, or the radial extensors of the wrist, elicits pain along the lower half of the radial border of the left forearm. All motion is associated with faint crepitus, which is attributed to the occupational synovitis. The affection appears in the more rapid workers, and enforces complete abstinence from work for a period of about two weeks.

Salicylates by mouth and gentle stroking massage seem to accelerate the cure.

ENFERMEDAD DE KOEHLER-PELLEGRINI-STIEDA (Köhler-Pellegrini-Stieda Disease). Luis Peralta. p. 187.

This condition may appear following a single trauma, or after repeated minimal traumata. Genu valgum, which unduly strains the tibial collateral ligament, predisposes to the development of symptoms. The author divides the course of the affection into four general phases: (1) the preroentgenographic phase, characterized by swelling and pain; (2) the roentgenographic phase, in which para-articular shadows appear; (3) the period of organization of the para-articular ossification; and (4) the period of regression.

In the first period, the author recommends rest and the application of an immobilizing plaster splint. Ice bags should be applied, and repeated injections of novocain should be given. Roentgenotherapy may be of use in ameliorating the pain. In the later stages, novocain loses its potency, and greater reliance must be placed upon the use of the roentgen ray.

Once the osteoma is fully formed, the author counsels the use of diathermy or heat in any form. Removal of the ossified mass is undertaken only for excessive pain.

Thirteen cases are briefly described.

THE ARTHROPATHIES. A HANDBOOK OF ROENTGEN DIAGNOSIS. Alfred A. de Lorimier, A.B., M.A., M.D. Chicago, The Year Book Publishers, Inc., 1943. $5.50.

The Year Book Publishers, Inc., have published "The Arthropathies", one of a series of handbooks on roentgenographic diagnosis.

The author, Colonel Alfred A. de Lorimier, who is Commandant of The Army School of Roentgenology, Memphis, Tennessee, has used the least number of words to fulfill his objective, which is to point out the direct and indirect evidence forming the criteria for an analytical interpretation that will lead to trustworthy diagnoses from roentgenograms of joints.

The diseases affecting joints have been grouped according to etiological considerations, facilitating use of the book as a reference in a given case. Each individual disease is described concisely as to synonyms, roentgenographic criteria, corroborative roentgenographic criteria, incidence, history, physical findings, clinical course, and bibliography. The narrative is conveniently interspersed with 654 roentgenographic reproductions to demonstrate the specific information given.

This book will be valuable as a text for students and is an excellent reference for anyone dealing with joint disease, from practitioner to specialist. More need not be said in tribute to the author.

THE RADIOLOGY OF BONES AND JOINTS. James F. Brailsford, M.D., F.R.C.P. Ed. 3. London, J. & A. Churchill Ltd., 1944. 45 shillings.

The third edition of Dr. Brailsford's book represents an analysis of his work during the past twenty-five years or more. In the years which have intervened since the first edition, attention has been focused on the recognition of early signs characteristic of definite lesions. Careful follow-up has revealed the ultimate fate of the lesions. This new edition presents a comprehensive picture of each entity.

The author stresses the importance of frequent roentgenographic examination, particularly in diseases where sudden changes may become manifest. Particular attention has been given to the changes in bones and joints resulting from trauma, the osseous dystrophies, tuberculosis, syphilis, and neoplasms.

Each part of the bony structure is discussed with its own peculiar susceptibilities to changes and disease. The presentation is clear and thorough, and excellent roentgenograms illustrate each section. The effect of the structures in the soft tissues upon the appearance of the underlying conditions is also considered.

Radiation therapy of bone lesions is given careful consideration.

The accurate interpretation of roentgenograms is a most important factor in the establishment of diagnoses, in following the development of certain lesions, and in determining the treatment indicated.

The full bibliography and complete index, prepared by the author personally, are other features which make this work a valuable reference book.

MINOR SURGERY. Frederick Christopher, S.B., M.D., F.A.C.S. Ed. 5. Philadelphia, W. B. Saunders Company, 1944. $10.00.

Christopher's Minor Surgery, since its initial publication, has rightly been considered one of the foremost surgical textbooks for the medical student, the intern, and the general practitioner. Indeed it might be said that there is no one in the medical profession who would not gain from using it as a very handy reference book.

Its chief attributes, to the reviewer's thinking, lie in its universality of subject matter, its enormous bibliography, and its presentation of divergent or conflicting theories or techniques, which cannot fail to interest the reader to inquire more fully into the matter at issue by referring to the original articles.

In this, the fifth edition, one is impressed by how completely the author has brought the work up to date, including an excellent summary of the uses of the sulfonamides, and even a short outline of the use of penicillin. A revised section on burns is very complete, including all the modern forms of therapy.

The section on surgery of infections and injuries of the hand is particularly excellent, and should do much good, as the knowledge of the proper care and technique in these instances is by no means sufficiently widespread.

It is to be regretted that the author chose to illustrate Didot's operation for syndactylism as prominently as he has on page 705, as it appears simple and rational to the beginner; but rarely produces a satisfactory result, as a commissure is not constructed by this method.

The last three chapters, which include much new material, should be particularly acceptable to the student and the intern, as they deal with the fundamental surgical principles underlying technique, preoperative and postoperative care, and an intern's responsibilities.

MEDICAL PHYSICS. Otto Glasser, Ph.D., Editor-in-Chief. Chicago, The Year Book Publishers, Inc. $18.00.

The Year Book Publishers undertook a tremendous task in compiling this excellent book of over 1700 pages. It is intended to be a combination encyclopaedia, textbook, and working instrument, in which may be found the data necessary for actual application of the principles of physics to medicine. Such a book was urgently needed. The contributors to the volume include many authors recognized as authorities in their fields.

Among the subjects considered in detail are: bio-electricity, biometry, centrifugation, climatic factors, electrocardiography, electro-encephalography, the electron microscope, electrosurgery, fluorescence, microtomy, optics, photo-electricity, photography, photometry, photomicrography, radio-activity, roentgenography, spectrographic analysis, temperature, vestibular mechanisms, and vision; also such subjects as gait, genetics, electric-shock therapy, fever therapy, hemolysis, physical anthropology, physical therapy, radiation therapy, refrigeration therapy, sedimentation, shock, tissue culture, tissue repair, and virus studies.

The many illustrations and diagrams help to clarify the material. A comprehensive subject index makes it possible to find easily the information desired.

This volume should prove a valuable reference book to all working in the fields of the medical sciences.

TRAUMATOLOGÍA DE GUERRA (Traumatology of War). Dr. Terencio Gioia. Buenos Aires, Aniceto Lopez, 1943.

This is an excellent monograph of 172 pages dealing with traumatic surgery of war. It is from a series of conferences on war surgery held in the P. Pinero Hospital in Buenos Aires, and is quite comprehensive in its scope. In general, a wise plan is followed of discussing general principles rather than going into minute detail in dealing with various types of cases. The first part of the first chapter describes the detailed method of actually handling battle casualties,—collection, transportation, places of treatment, and finally evacuation to regular or special Base Hospitals. The remainder of the first chapter deals with blast injuries, gas injuries, bullet wounds, grenade wounds, and shell-fragment wounds.

The second chapter deals with wounds of the soft tissues, and certain fundamental principles are stressed,—such as, treatment of shock, removal of necrotic tissue, secondary wound closure, and complete rest of the affected part.

The third chapter is concerned with the treatment of wound infections. Of special interest to the orthopaedic surgeon are the chapters which deal with wounds of joints and bones. The recommended treatment for joint injuries is essentially standard treatment in the United States, and consists of thorough cleansing of the joint and primary suture where possible: where this is not possible and the joint must be left open, irrigation and early motion are the rule. The treatment of some specific joints is discussed in detail.

The chapter dealing with fractures discusses the treatment of various fractures, and in general it is very good. A good deal of space is given to the treatment of infection in fractures. In this connection it is of interest that, in the primary treatment of the wound, iodine rather than the sulfonamides is stressed.

The last two chapters of the book are given over to a detailed consideration of cranial injuries of war.

MEDICAL RADIOGRAPHIC TECHNIC. Prepared by The Technical Service Department of General Electric X-Ray Corporation under the Editorial Supervision of Glenn W. Files, Director. Springfield, Illinois. Charles C. Thomas, 1943. $6.00.

This book was originally developed as a guide in formulating a standard method of teaching x-ray operative procedure. It is definitely a good departmental reference book for hospitals and offices, especially those equipped with modern General Electric diagnostic apparatus.

The first five chapters deal with fundamental electrical concepts,—electron theory and the x-ray tube, basic x-ray generating circuits, x-ray apparatus, and radiographic calibration. This material is presented very concisely and clearly in only seventy-five pages. The reader is supposed to have a knowledge of college physics. The numerous drawings, charts, and graphs are exceptionally clear, simple, and plainly lettered. These pages should be useful to the average physician or technician who desires a rapid review or outline of the essential design, mechanism, and limitations of modern shockproof x-ray apparatus. It is obvious, however, that the authors have purposely omitted all circuits and apparatus, with one exception, that are not incorporated in the modern x-ray equipment made by their Company.

Factors affecting the quality of the radiograph are considered in detail. Mr. Files is a recognized authority in this field and his discussion is valuable. The subjects of stereoscopy, planigraphy, foreign-body localization, fluoroscopy, soft-tissue radiography, and photofluorography are treated only briefly. It is noteworthy that the precautions and procedures used to shield operators and patients from the harmful effects of x-rays are quoted verbatim from the "Recommendations of the International Roentgen-Ray Committee on X-ray Protection."

The most practical part of the book, from the technician's viewpoint, is the atlas on positioning and technique. The illustrations are self-explanatory. Each standard position is photographed on a separate page. A mirror, placed at a certain angle beyond the patient, enables the reader to visualize simultaneously the top and side surfaces of the patient. The direction of the central ray is sketched into the photograph. Usually a small anatomical diagram is also included. The same page also shows a reproduction of the resultant radiograph in addition to a written description of the position with technical data.

In conclusion, this book will serve the useful rôle of a guide or handbook to general radiographic technique. Specialized subjects, such as ventriculography, encephalography, myelography, arthrography, the use of iodized oil, kymography, pelvimetry, and the preparation of patients for gastro-intestinal and genito-urinary work are not discussed. All references and historical data are also omitted.

AN ATLAS OF ANATOMY (In Two Volumes). Volume II. VERTEBRAE AND VERTEBRAL COLUMN, THORAX, HEAD, AND NECK. J. C. Boileau Grant, M.C., M.B., Ch.B., F.R.C.S.(Edin.). Baltimore, The Williams and Wilkins Company, 1943. $5.00.

The second volume of this excellent anatomy will be especially appreciated by those who have found of great assistance Volume I, which dealt with the upper limb, abdomen, perineum, pelvis, and lower limb.

This present volume includes the vertebrae and vertebral column, thorax, head, and neck, and will be found a most helpful guide in the better understanding of these regions, as well as a valuable reference book when questions arise about the anatomy of these structures.

The great care with which the specimens were prepared for the artist accounts in part for the excellence of the illustrations, which make these two volumes of so great value.

PHYSICAL FOUNDATIONS OF RADIOLOGY. Otto Glasser, Ph.D.; Edith H. Quimby, Sc.D.; Lauriston S. Taylor, Ph.D.; J. L. Weatherwax, M.A. New York and London, Paul B. Hoeber, Inc., 1944. $5.00.

The authors have been instructing physicians preparing to enter the field of roentgenology, and have been presenting shorter courses and special lectures for those already in the specialty and desirous of review or further information. The volume presented is primarily for their use, and is intended to be elementary and non-mathematical. The authors advise the supplementary use of more advanced textbooks for teaching in medical schools.

The subjects covered include a short history of roentgenology, and discussions on the fundamental concepts of matter, on the nature of radiations, the fundamentals of electricity and magnetism, high voltage generators, roentgen-ray tubes, the production and nature of x-rays, the interaction of radiation and matter, radio-activity, the measurement of gamma rays, neutrons and artificial radio-activity; as well as explanations of roentgenographic diagnostic procedures, the measurement of x-ray quantity and quality, tissue dosage in x-ray therapy, radium dosage, and biological reaction. Depth-dose tables for the roentgen ray are also included. Protection against exposure to roentgen ray and radium is stressed and explained in some detail.

CLINICS, II, February 1944. Philadelphia, J. B. Lippincott Company. Single issue, cloth, $3.00.

The February issue of *Clinics*, edited by Dr. George Morris Piersol and published by J. B. Lippincott Company, is devoted for the most part to a "Symposium on War Medicine". This Symposium is based on the papers and recorded discussions presented as teaching panels at the Fifty-First Annual Meeting of the Association of Military Surgeons of the United States, which was held in Philadelphia, October 22 and 23, 1943.

The two panels on "Chemotherapy"—one on "Pharmacology and Toxicology", and the other on "Application and Results"—were led by Dr. Chester S. Keefer. "Plastic and Reconstruction Surgery", with Dr. Robert H. Ivy as Chairman; "Fatigue", with Dr. Arlie V. Bock acting as Chairman; and "War Wounds and Burns", under the leadership of Brigadier General Fred Rankin, provided opportunities for the reports of men who had had extensive experience in the Armed Forces as well as of those in civilian practice.

Of special interest is the chapter on "Fractures", reporting the panel led by Captain Camille M. Shaar, and giving the comparative figures for various types of treatment of fractures, as observed by the speakers, especially in war casualties.

THE SIMILARITY OF CLINICAL AND ROENTGEN FINDINGS IN CHILDREN WITH EWING'S SARCOMA (ENDOTHELIAL MYELOMA) AND SYMPATHETIC NEUROBLASTOMA. Robert Phelps Barden. *The American Journal of Roentgenology and Radium Therapy*, C, 575, 1943.

The typical roentgenographic appearance of the bone lesions in Ewing's sarcoma and in sympathetic neuroblastoma is well known. However, it is not sufficiently appreciated that the roentgenographic picture of these two diseases can be identical. This fact is made more interesting by the marked histopathological similarity between these two diseases.

The author was afforded the opportunity of studying four children, two of whom died of Ewing's sarcoma, and two of sympathetic neuroblastoma. The clinical and roentgenographic findings were so similar that a differential diagnosis before death was impossible. The histopathological material from each case was reviewed by several pathologists.

In his discussion, Barden does not wish to add to the confusion and controversy which exist on the pathogenesis of Ewing's sarcoma and sympathetic neuroblastoma. Although he takes no definite stand on whether these two diseases are one complex or whether they are distinct tumors having the same biological attributes, he favors the latter hypothesis in view of his cases.

By so widening the diagnostic concept of these diseases, two important practical applications as regards the therapy of Ewing's tumor are suggested:

First, amputation for cure should probably not be attempted in cases diagnosed upon the best evidence as Ewing's tumor. This statement is made in spite of the knowledge that a few patients are alive five years after the removal of a solitary Ewing's tumor. Ewing, himself, mentions one of these who died, from irrelevant disease, nine years after amputation; the postmortem examination showed residual tumor cells in the retroperitoneal lymph nodes.

Second, the cases presented indicate that roentgen irradiation to the retroperitoneal region should be given in Ewing's tumor, since it is so often impossible to determine before death the presence of abdominal tumors.—*Richard C. Batt, M.D., Berlin, New Hampshire.*

COMBINED ANTERIOR AND POSTERIOR SPINA BIFIDA IN A LIVING NEONATAL HUMAN FEMALE. R. L. deC. H. Saunders. *The Anatomical Record*, LXXXVII, 255, 1943.

The author reports a case of rachischisis anterior and posterior,—combined spina bifida, in a neonatal female, two days old, extending from the first lumbar to the second sacral vertebra. A red mass of mucous membrane, communicating with a hernial loop of large intestine, projected through a fistula in the lumbar region of the back. The mass increased in size and faeces were excreted *per fistulam et anum*. The child lost weight and died of sepsis in her fifth month.

The vertebral column was discovered to be normal down through the seventh thoracic vertebra. The eighth lay obliquely; a composite piece included the ninth and the right half of a deficient tenth; and a diamond-shaped eleventh and triangular twelfth followed. Hemivertebrae flanked the vertebral cleft, to-

gether with a laminar ridge on either side, formed by their fused half arches. The spinal cord bifurcated unequally at the upper end of the cleft, the left division being the larger; the right section gave off a single laterally directed set of nerves, and the left, both a lateral and a medial set. The nuclei pulposi found between the right hemivertebrae were larger than those between the left.

In discussing the etiology of this anomaly, the author considers the theory of Feller and Sternberg,—that a primitive knot-cell rest persists in the mid-line, causing a notochordal cleft, and that this in turn causes the vertebral centra to be laid down in two independent halves. He, himself, regards a double or cleft notochord as the starting point of these abnormalities, associated with an ento-ectodermal adhesion which interferes with the fusion of the sclerotomes and results in a series of hemivertebrae. He reviews thirty-seven cases of combined spina bifida, previously reported in the literature.

VENOUS HEMANGIOMA OF SKELETAL MUSCLE. CASE REPORT. Rudolph A. Light. *Annals of Surgery*, CXVIII, 465, 1943.

Venous hemangioma of skeletal muscle is not common. It is generally conceded to be a congenital condition, but the reason for delay of onset of symptoms is not known. The onset of symptoms in 79 per cent. of cases is before the twentieth year, and in 94 per cent. before the thirtieth.

The most frequent symptom is pain, which in only a few instances is paroxysmal.

The author reports a case in a white male, aged sixteen years. Two years before, a slightly tender area on the posterolateral surface of the right knee, without previous trauma, had been noted. The pain had increased in severity, until he walked on the toe of his foot with his knee flexed, and finally ambulation had become almost impossible.

Examination showed an area of excruciating tenderness over a three-centimeter area just behind and medial to the head of the right fibula. No palpable mass was present. Reflexes were normal, and there were no sensory abnormalities consistent with disease of the peripheral or central nervous system. The right calf was three centimeters smaller than the left. Skin temperature of the two extremities was normal. Laboratory studies were not significant and roentgenograms showed no abnormalities. A preoperative diagnosis of glomus tumor was made.

An operation was performed, and on the deepest aspect of the lateral head of the gastrocnemius was found an area approximately two by three centimeters "having the appearance of cavernous hemangioma in which were flecks of yellowish tissue". No connection with the peroneal or posterior tibial nerves or vessels could be demonstrated.

After the operation, the leg was put in traction with the foot at a right angle to the leg for six days. The patient began to walk on the seventh day and was discharged on the ninth, at which time he still had considerable flexion deformity.

He was seen again two years and ten months after operation. At this time the only abnormality present was the defect in the medial aspect of the lateral head of the gastrocnemius. Pain had not been experienced after his discharge from the hospital, and the flexion deformity of the knee had gradually disappeared during a period of three to four months.

The first pathological report was glomus tumor, but on review of the published reports of glomus tumor, only three of which had occurred in deep structures away from the ends of the extremities, the author doubted the diagnosis, and submitted the sections to Dr. A. P. Stout, who made the diagnosis of venous hemangioma.

AFFERENT VASODEPRESSOR NERVE IMPULSES AS A CAUSE OF SHOCK: TESTED EXPERIMENTALLY BY AORTIC-DEPRESSOR NERVE STIMULATION. Dallas B. Phemister, Carl H. Laestar, Lillian Eichelberger, and R. J. Schachter. *Annals of Surgery*, CXIX, 26, January 1944.

Phemister and his associates tested the validity of the commonly held concept that primary shock is the result of excessive impulses of the afferent depressor nerves, set up in the wound or in the cerebrum. In this concept, it has been assumed that these afferent impulses act upon the vasomotor center, and to a less extent upon the cardiac center in the medulla.

The experimental method involved the use of rabbits, and in them were studied the effects produced by stimulation of the aortic-depressor nerves. This procedure was chosen as being the simplest and most efficient of three experimental methods of producing marked and prolonged lowering of blood pressure. The production of shock might have been attempted by the stimulation of somatic nerves or by the stimulation of the depressor centers in the cerebrum.

The various experiments are carefully described, and the results are clearly set forth. It was found that stimulation of the aortic-depressor nerve would maintain the blood pressure at shock levels for hours, without serious impairment of the tissues or of the circulation. If continued too long, death might follow from the effects of hemodilution, anoxia, and damage to the vasomotor centers, a condition which might be called neurogenic shock.

The relative harmlessness of these periods of low blood pressure, and the inability to produce more than

brief and slight lowering of blood pressure by stimulation of somatic nerves carrying impulses from traumatized fields, together with the short periods of reflex lowering of blood pressure during syncope, are the findings upon which it is concluded that "it is extremely improbable that primary shock is ever produced in man by the action of afferent depressor nerve impulses". Therefore, the term "primary shock" to designate such a condition should be given up.

It was also found that death was hastened somewhat by first lowering the blood pressure by hemorrhage and still further lowering it by stimulating the aortic-depressor nerve. This result was also produced by first lowering the blood pressure for from one to four hours, and then bleeding the rabbits. Judging by these experimental results in rabbits, it is concluded that, in the presence of low blood pressure in man produced by hemorrhage, fainting, or the occurrence of a reflex drop in blood pressure from abdominal manipulation may be a contributing factor in shock. Clinical experience lends support to this conclusion.—*Paul P. Swett, M.D., New York, N. Y.*

STUDIES ON TRAUMATIC SHOCK: I—BLOOD VOLUME CHANGES IN TRAUMATIC SHOCK. Everett Idris Evans, M. J. Hoover, G. Watson James, III, and Theodore Alm. *Annals of Surgery*, CXIX, 64, January 1944.

Because this was a clinical study, it was first necessary to discover whether, as has long been supposed, there exists in shock an increased capillary permeability. Using the Gregersen-Gibson method for the estimation of plasma volume in dogs, it was found that the rate of dye disappearance was essentially the same for the same dog in the normal state and in the state of shock. From use of the same method in more than 500 determinations of plasma volume in both the normal and the shock states in patients, the authors are convinced that it gives valid data for the estimate of the plasma volume in shock. From their experience in both experimental and in clinical shock, the authors are certain that increased capillary permeability does not occur.

Hematocrit values in clinical shock showed so little evidence of blood concentration as to lead to the conclusion that what is lost in traumatic shock is whole blood and not its liquid component. Nothing, therefore, is gained by an estimate of the specific gravity of the blood in early shock. This leaves the study of the blood-pressure levels as the most important observation, since these levels are consistently low,—so consistently low that it is possible by studying the blood pressure levels and the type of the injury, together with the state of the patient, to estimate quite accurately the plasma volume.

The clinical cases in this series (143 in all) were divided into four classes, those due to: (1) acute blood loss, (2) skeletal trauma, (3) abdominal injuries, and (4) chest injuries. Regardless of the class, the average blood loss in severe traumatic shock was about 38 per cent. In no class were there signs of severe shock until the blood loss exceeded 15 per cent.

Both the clinical and the experimental findings clearly indicate that extreme blood loss at the site of the injury is the most important single factor in the cause of traumatic shock, although in many patients there undoubtedly is a preliminary fall in blood pressure, due to neurogenic causes. In certain recent studies, the opinion was expressed that decreased cardiac output precedes a lowering of blood pressure, but from the observations of Evans and his associates, it is believed that lowered blood volume is present before lowered cardiac output.—*Paul P. Swett, M.D., New York, N. Y.*

FIXAÇÃO DO CONDILO EXTERNO DO ÚMERO COM O FIO DE KIRSCHNER (Fixation of the External Humeral Condyle with a Kirschner Wire). Bruno Maia. *Boletin do Instituto de Assistência Hospitalar*, III, 25, 1942.

The author reports four cases of fracture of the external humeral condyle in children. In the presence of a rotary displacement of the fractured condyle, an open reduction of the fracture with fixation by a Kirschner wire is considered by the author as the indicated treatment. The wire is introduced through the skin under fluoroscopic control, and immobilization is secured with plaster-of-Paris. Of the four cases, three were reduced by operation, and one by manipulation. The Kirschner wire was introduced in all four cases, and the results obtained were satisfactory.—*Emanuel B. Kaplan, M.D., New York, N. Y.*

FRACTURA PATOLÓGICA DEL CUELLO DE FÉMUR. OSTEOMÍA DE APOYO (Pathological Fracture of the Neck of the Femur). José A. Sgrosso. *Boletines de la Sociedad de Cirugia de Rosario*, X, 26, 1943.

The author reports a case of an Argentinian young woman of seventeen years, who was treated at the Italian Garibaldi Hospital of Rosario, Argentina.

The patient had always enjoyed excellent health. In September 1939, she suddenly began to feel local pain in the right hip, with a slight claudication.

A roentgenogram taken in January 1940, showed a fracture of the neck of the femur.

The hip was immobilized for about a year, but the pain increased, and she could not walk without the aid of a cane.

In 1942 she entered the Garibaldi Hospital. A roentgenogram showed a pathological fracture of the neck of the femur, with accentuated coxa vara and elevation of the diaphyseal stump. The osteolytic process destroyed a good deal of the femoral neck and caused alterations in the epiphysis.

The author's therapy consisted of the following:

1. Application of skeletal traction.
2. Oblique intertrochanteric osteotomy with internal displacement of the distal fragment. A Steinmann nail was used, as advised by Reich, to bring the osseous fragment into the right place.

The author claims that the use of the intertrochanteric osteotomy in the treatment of pathological fractures of the neck of the femur is rather rare. Prof. Putti of the Istituto Rizzoli was supposedly the first to describe intertrochanteric osteotomy treatment of pseudarthrosis, in the Italian journal, *La Chirurgia degli Organi di Movimento*, October 1939. This treatment has been extended to other pathological cases, especially osteo-arthritis.—*Victor Richards, M.D., San Francisco, California.*

TRATAMIENTO QUIRÚRGICO DE LA EPIFISEÓLOSIS CLAVICULAR (Surgical Treatment of Clavicular Epiphysiolysis). M. A. Karlen. *Boletín de la Sociedad de Cirugía del Uruguay*, XIV, 94, 1943.

Epiphyseal separation of the inner end of the clavicle is an extremely unusual injury. This condition can occur only in patients under the age of twenty years, before union of the medial epiphysis. Clinically, it resembles dislocation of the sternal end of the clavicle. The deformity is similar to that found in dislocation of the sternal end, or in fracture of the inner end of the clavicle.

Treatment may be conservative, as by means of the Sayre dressing, or the Böhler splint. The author, however, recommends surgical intervention as being more certain in result and less annoying to the patient. The area is exposed through a fishhook-shaped incision, along the under surface of the clavicle and over the sternoclavicular joint. Once the site is exposed, three No. 3 chromic sutures are used to fix the inner end of the clavicle. The first is passed through the uncovered end of the clavicle, through the epiphysis, and then through the upper angle of the sternum. The second suture is passed through the costoclavicular ligament, around the clavicle, to the clavicular head of the sternomastoid. The third is passed around the clavicle and is inserted into the costoclavicular ligament, at its origin on the first rib. After closure of the wounds, the patient is dressed in a figure-of-eight clavicular bandage, which is left on for a period of five weeks. Active use of the arms is permitted from the very beginning.—*Henry Milch, M.D., New York, N. Y.*

RUSSIAN SURGEONS AND RUSSIAN SURGERY. R. Watson-Jones. *The British Medical Journal*, II, 276, 1943.

The author, as a member of a group of British surgeons who recently visited the U.S.S.R. under the auspices of the Medical Research Council and the British Council, has had an opportunity to observe Russian surgeons at work, and writes an interesting report of what he has seen.

Emergency evacuation hospitals are located within ten or twenty miles of the front lines, and treatment by skilled specialists is instituted within twenty-four to forty-eight hours after injury. Upon reception from front-line hospitals, patients are assigned to special wards,—orthopaedic, neurosurgical, thoraco-abdominal, lightly wounded, *et cetera*. Each 200-bed ward is provided with its own operating theater and x-ray equipment. Every third or fourth day, each ward empties and refills as patients are evacuated to the rear. The principle of segregation is carried beyond the specialist wards of sorting-evacuating hospitals to specialty hospitals further behind the lines. So great has been the flow of casualties that it has been practicable to devote 2,000-bed hospitals to gunshot fractures of the thigh, to penetrating wounds of the hip joint, and to other special injuries.

The closed-plaster technique is used for all major wounds, including compound fractures, and joint injuries. Professor Yudin, with whom the author discussed orthopaedic procedures, said that, in the surgery of war, this was first practiced in the War of 1859 by the famous Russian surgeon Pirogof, who amazed his Italian and French colleagues with his method. After excision of the wound, Yudin avoids the use of any tube, drain, gauze pack, or other "foreign body", and applies an unpadded plaster cast directly over the wound. Contrary to the British method, as the author says, of free excision within the first twelve or possibly twenty-four hours, and incision and drainage in late cases, Yudin recommends a large excision of all injured and contused tissues, no matter how many hours or days have elapsed since the wounding and "independently of the presence and degree of infection". He considers simple incision and tamponade with gauze as a temporary measure, and not as surgical treatment.

In joint wounds, although resection of the joints was favored at first, more recently arthrotomy of acutely infected joints has been advocated.

The author touches briefly upon craniocerebral wounds, upon blood transfusion, and upon new operations in other fields of surgery.

COXA ANTEVERTA VERSUS ANTEVERSION OF THE FEMORAL NECK. Henry Milch. *Bulletin of the Hospital for Joint Diseases*, IV, 79, 1943.

In development of previous studies concerned with epiphysiolysis of the femoral neck and congenital

dislocation of the hip, the author presents a clarification of the terms "anteversion of the femoral neck" and "coxa anteverta" in conjunction with the corresponding methods of treatment. Anteversion of the neck, although accepted as such by common practice, is really an internal rotation of the shaft of the femur in relation to the neck. "Coxa", which is used instead of "collum", is accepted as meaning neck of the femur. The author emphasizes the importance of differentiation of the term anteversion of the neck of the femur and the term "coxa anteverta". Anteversion of the neck of the femur means an increase in the angle between the axis passing through the head and neck of the femur and the bicondylar axis of the lower end of the femur. It varies normally between 12 and 25 degrees, and may reach 90 degrees in pathological cases; it is encountered frequently in congenital dislocations of the hip. The treatment would require an osteotomy with external rotation of the distal fragment.

Coxa anteverta designates a condition in which a dissolution occurs between the head and neck of the femur, with an anterior angulation of the neck at the epiphyseal line, the angle between the neck and the shaft of the femur or the bicondylar line remaining normal. The correction of this deformity in the late stages would require an osteotomy with internal rotation of the distal fragment, in contrast to the osteotomy with external rotation required in anteversion of the neck.—*Emanuel B. Kaplan, M.D., New York, N. Y.*

Acute (Febrile) Polyarthritis in the Army. G. C. Ferguson. *The Canadian Medical Association Journal*, XLIX, 492, 1943.

During the year ending July 31, 1942, 534 patients with various types of acute arthritis were admitted to Canadian military hospitals, 331 in the period from February to May 1942. The cases reviewed by the authors do not include patients having rheumatic fever, but only those with acute (febrile) polyarthritis (243).

In 58 per cent. of the patients studied, arthritis developed within twelve weeks of an acute infection, usually streptococcus hemolyticus. A high blood-sedimentation rate accompanied the disease, and a high pulse rate frequently indicated cardiac involvement (110 patients). Symptoms included swelling of the joint or joints involved, in most cases in the knee or ankle; redness; pain upon movement; local heat; and finally effusion. Salicylates, in dosages of 120 grains per day, gave excellent results, reducing the fever and joint symptoms usually within a few days.

The patients were not returned to active duty until temperature, pulse, joints, white-blood count, and blood-sedimentation rate had returned to normal.

Of these cases, 50 per cent. were dismissed from the Army,—35 per cent. for cardiac disease, 7 per cent. for progressive arthritis, and 8 per cent. for chronic joint pain with no clinical findings. A large percentage of these patients, who could not be retained in the Army, gave a history of previous attacks.

Nuestra Conducta en las Fracturas Intracapsulares del Cuello del Fémur (Our Conduct of Intracapsular Fractures of the Neck of the Femur). Juan Farill. *Gaceta Medica de Mexico*, LXXIII, 185, 1943.

This is a long, well-organized, and well-written article covering all aspects of the problem of the treatment of fractures of the neck of the femur. The former poor and now much better prognosis is discussed. The circulatory and mechanical factors involved are brought out, and the value of internal fixation in fresh fractures is emphasized. The various types of treatment which have been used and are being used are briefly described. The author's objection to the Smith-Petersen nail is that he has found that it does not securely hold the fragments together, but allows them to work loose. The threaded wires used by Compere he likes much better, but he feels that a bone graft is necessary to ensure adequate blood supply and good union. The method he uses consists of applying a bone graft with a threaded Kirschner wire on each side of it. There follows a discussion of the various methods of treating non-union of fractures of the neck of the femur, in which he concludes that a high osteotomy is superior to other methods. The author originated independently, sometime about the middle of 1942 (the exact date is not given), a method of retaining the high osteotomy by means of a Neufeld nail, bent in a Z fashion,—a method very similar to those of Blount and Austin Moore. An osteotomy is done transversely below the greater and above the lesser trochanters; a wedge of bone is removed; the nail is driven across the old fracture site; the osteotomy is placed in alignment; and the shaft of the nail is applied to the shaft of the femur. No cast is used postoperatively. The advantages of this method are pointed out, and the principles behind it are given.—*Major Louis W. Breck, M.C., Camp Swift, Texas.*

Posterior Subastragaloid Arthrodesis in Fractured Os Calcis. J. R. Armstrong. *The Lancet*, II, 506, 1943.

Armstrong points out that damage to the subastragalar joints is the dominant factor in producing disability in fractures of the os calcis. He describes a technique for arthrodesis of the posterior subastragalar joint by the usual approach and excision, combined with a tibial graft which is inserted as follows: A

second short incision is made over the anterior aspect of the neck of the astragalus; the limits of the tibial and the scaphoid articular surfaces are defined; and, while the foot is steadied by an assistant, a bed is prepared through the neck of the astragalus and into the body of the os calcis by the use of drills and small chisels. While the chisel is in place, the position of the bed is checked roentgenographically and, if correct, the graft is driven home. Three weeks after the operation, an unpadded plaster cast is applied; a rubber heel is attached; and weight-bearing is begun. The author points out that the insertion of the graft immobilizes the subastragalar area, maintains anatomical relationships between the astragalus and the calcaneum, and aids in avoiding disturbance in the relationship of the other tarsal joints.—*Lenox D. Baker, M.D., Durham, North Carolina.*

ORTHOPAEDIC INFLUENCE ON THE TREATMENT OF FRACTURES. A CLINICAL STUDY. G. R. Girdlestone. *The Lancet*, II, 593, 1943.

Mr. Girdlestone's Presidential Address was delivered before The British Orthopaedic Association, on October 29, 1943, at the meeting held in London. In it a strong appeal is made for the better treatment of fractures throughout Great Britain, through the employment of sounder principles of treatment and improvement in the medical organization developed for their care. To the latter end, two conditions are held to be essential: (1) the selection of the men in each district most suited by training and ability for the primary care of fractures, and (2) the transfer to qualified experts of the difficult fractures, particularly those endangering joint function.

Emphasis is convincingly laid on the superiority of skill in the use of "simple and straightforward means" over the haphazard employment of complex gadgets in fracture treatment.

Mr. Girdlestone discusses the basic principles underlying the healing of bone, the restoration of soft part and joint function, and the rehabilitation of the disabled patient. The importance of active hyperaemia, the dangers of powerful traction, and the necessity of restoration of the joint contours, and early function without weight-bearing in joint fractures are ably stressed.

The fractured-scaphoid problem is reviewed, and more frequent use of conservative measures and less open surgery is urged. There is given a sound word of caution against elaborate surgical procedures, carried out by less experienced operators who could achieve better results by simple, non-operative measures.

Mr. Girdlestone's views on fracture of the neck of the femur and "the dead head" are stated at some length. They are both provocative and profound. No one can question his strong stand for accurate reduction.

This is a powerful address, and all employed in the care of fractures will find it of great value.

GUNSHOT WOUNDS OF THE ELBOW-JOINT. St. J. D. Buxton. *The Lancet*, II, 663, 1943.

Buxton, after the third Libyan battle in the summer of 1942, collected records from the files of the Middle East Forces of fifty-one wounds involving the elbow joint. The basic principle of the forward operation was to "treat the wound" rather than to spend time on dealing with the fracture or joint injury. Hence the operation carried out was excision of skin edges and necrotic tissue, followed by removal of loose pieces of bone. Hemostasis was obtained; the wound was dusted with sulfanilamide; a soft paraffin-gauze pack was inserted; and the limb was placed in plaster-of-Paris from the axilla to the metacarpal necks. A plaster cast appears to have been used routinely. A sling was applied, and the patient was transported to the base. The course of oral sulfanilamide, already started, was continued until twenty to twenty-five grams had been given in five days.

The shortest period that elapsed between the time that the wound was received and arrival at a base hospital was forty-eight hours and the longest eleven days.

In thirty-one of the fifty-one extremities treated, a suppurative arthritis developed. In all but three cases, there was a fracture; and in at least four-fifths of them, a bone was seriously damaged. Nerve injury was seen in fourteen cases. The author states that he has been impressed by the results of excision of the mutilated olecranon process. He points out that drainage of the joint is free, and a second operation is seldom necessary. The wound granulates quickly, and the end results are better than in the cases treated by other methods.

Two amputations were carried out because of the extent of the wounds; none were required because of septicaemia from suppurative arthritis.—*Lenox D. Baker, M.D., Durham, North Carolina.*

INFECTED BURNS AND SURFACE WOUNDS. THE VALUE OF PENICILLIN. D. C. Bodenham. *The Lancet*, II, 725, 1943.

Bodenham points out that penicillin is more active than the sulfonamides in eliminating streptococci and staphylococci from burns in surface wounds. It removes streptococci which resist the sulfonamides. It does not affect the bacillus proteus or the bacillus pyocyaneus. He found that penicillin in strengths up to

twenty units per square centimeter has no adverse effect on skin grafts, and that its use facilitates grafting of raw surfaces. Penicillin applied in a cream base, formed with lanette wax and soft paraffin, with a concentration of 100 Oxford units per gram, was found to be the most effective and economical means of applying the drug to wounds.—*Lenox D. Baker, M.D., Durham, North Carolina.*

TENDER MUSCLES IN SCIATICA. ELECTROMYOGRAPHIC STUDIES. Frank A. Elliott. *The Lancet*, I, 47, 1944.

Elliott, in a report on radicular sciatica with areas of deep muscle tenderness, points out that it is not generally recognized that tender spots, not distinguishable from the more benign forms of myalgia, both in their clinical features and their response to procaine, may be found in the muscles supplied by irritated nerve roots, where the irritation is central in origin rather than local, as a result of an inflammatory or rheumatic process which gives rise to referred sciatic pain. Use was made of the fact that contracting muscles give rise to action potentials which can be recorded. Electrodes were threaded through a hypodermic needle and led off through a high-gain amplifier to a cathode-ray oscilloscope with a loud-speaker attachment, allowing visual and auditory patterns of muscle activity to be observed. Resting muscle showed no activity with the amplifications used, whereas contraction was accompanied by characteristic action potentials. Elliott concluded that there is a form of myalgia arising in muscles supplied by an irritated root, which simulates so-called fibrositis, both clinically and in its response to local injection of procaine, and that this myalgia is responsible for a variable and sometimes considerable proportion of the patient's total discomfort. Relief obtained from procaine does not, therefore, exclude a root lesion. The electromyographic studies show that the tender spots in the muscles are, as a rule, the seats of localized increase of irritability and a continuous discharge of action potentials. On clinical grounds, he infers that this activity is not merely the sustained response of irritable muscle to the presence of the myogram needle, but also represents involuntary spasm of small groups of muscle fibers. He reports two cases which responded to procaine injections, but subsequently at operation were found to have root pressure.

This is a most interesting study and deserves further investigation.—*Lenox D. Baker, M.D., Durham, North Carolina.*

PATHOLOGY, CLINICAL MANIFESTATIONS AND TREATMENT OF LESIONS OF THE INTERVERTEBRAL DISKS. Albert Oppenheimer. *The New England Journal of Medicine*, CCXXX, 95, January 27, 1944.

The basis for this authoritative report lies in a study during the past eight years of 826 cases of disc lesions together with a control series of 200 persons without symptoms and another control series of 100 persons with complaints suggestive of disc lesions. There are two main groups of disc lesions: (1) those caused by rupture, and (2) those caused by degeneration. Thinning of the disc follows in both groups. At the level of this secondary thinning, the neural foramen is narrowed (92 per cent. in this series), and this may compress the nerve root, depending upon the amount of the initial clearance. Loss of the buffer action of the disc induces the formation of marginal osteophytes on the vertebra, but these are not symptomatic. Local pain occurs when hypertrophic arthritis develops in the apophyseal joints, but this was found in less than 20 per cent. of this series. Of the 200 persons without symptoms, 11 per cent. had flattened discs, while 85 per cent. of 312 patients who had disc thinning did have symptoms. Clinical manifestations suggestive of disc lesions are due, in 10 per cent. of the cases, to some other disease.

Regardless of the cause, flattening of the disc leads to narrowing of the intervertebral spaces, associated with displacement of the articular processes, narrowing of the neural foramen, and contact between the vertebral bodies. Most of the clinical manifestations are caused by these secondary alterations rather than by the primary disc lesion. Even rupture of the disc is not an invariable exception to this rule.

Disc lesions are about twice as common as duodenal ulcer. In the majority of cases, disc lesions cause symptoms in the limbs without accompanying signs or symptoms in the back itself. This, to repeat, is due to the fact that local pain occurs only when secondary alterations (discogenetic changes) are present in the apophyseal joints, and this incidence is less than 20 per cent. Local pain occurs in the lumbar region in about one-third of the cases of disc lesions. In the cervical region, local pain seldom occurs.

Treatment may be surgical or conservative, but even the removal of a ruptured disc together with spine fusion does not prevent future symptoms resulting from further thinning of the disc. Conservative treatment yields satisfactory results in 75 per cent. of the cases. Roentgen-ray treatment gave permanent relief in 21 per cent. of the cases and temporary relief in 55 per cent. The best results from roentgen-ray treatment were noted in the cases with trophic disturbances in the skin, muscles, and bones.—*Paul P. Swett, M.D., New York, N. Y.*

MULTIPLE MYELOMA: DIAGNOSTIC VALUE OF THE BLOOD SMEAR. Leopold Morissette and C. H. Watkins. *The Proceedings of the Staff Meetings of The Mayo Clinic*, XVII, 433, 1942.

This article is a summary of the results of 100 cases of multiple myeloma, in which blood smears were studied as a basis for diagnosis. The significant findings were: anaemia, excessive rouleau formations, im-

maturity of both erythrocytes and leukocytes, leukocytosis, eosinophilia, and the presence of myeloma and atypical plasma cells.

The anaemia is thought to be due to the effect of toxicity on the blood-forming elements in the bone marrow. Renal stasis with Bence-Jones proteinuria may be a cause.

The rouleau formation, which gives an unusual greasy appearance to the smear, seems to be the outstanding feature in this study. In twenty cases, the protein ranged to eight grams per 100 cubic centimeters (normal six to eight). The albumin-globulin ratio became one to three (normal ratio three to one); thus it was inverted in many cases. The greasy smears were found in cases where the hemoglobin was eight grams per 100 cubic centimeters, and the red blood count was 2,550,000. In the non-greasy smears, hemoglobin averaged 9.5 grams per 100 cubic centimeters, and the red blood count 2,900,000. The rouleau formations were less. Smears showed thirty-five to forty-five lymphocytes per 100 leukocytes. Eosinophils ranged from four to forty-four per 100. Myeloma cells measured twenty-five microns, and had large nuclei. All the varieties of myeloma cells and plasma cells were found in this study. When myeloma cells were found in slides, a diagnosis of multiple myeloma was justified. When myeloma cells were found in conjunction with atypical plasma cells, the same diagnosis was warranted. The basis for multipled myeloma has been debated, as to whether it is a subleukaemic entity or a neoplasm.

In conclusion, it may be said that the blood smear can be a valuable aid in the diagnosis of multiple myeloma, and that the plasma-cell type is predominant in frequency. Myeloma is probably closer to the leukaemias than to a neoplasm.—*A. J. Langan, M.D., Iowa City, Iowa.*

CONSIDERAÇÕES SOBRE A OSTÉO-SINTESE EXTRA-ARTICULAR DO CÓLO DO FEMUR COM A PROTESE DE GODOY MOREIRA (A Study of Extra-Articular Osteosynthesis of the Neck of the Femur by the Stud-Bolt Screw of Godoy-Moreira). Milton Weinberger. *Revista Brasileira de Ortopedia e Traumatologia* IV, 119, 1943.

The author describes in detail five cases of fracture of the neck of the femur treated by the method of Godoy-Moreira with modifications of the method. The modifications consist in the use of a special guide for wires transparent to roentgen ray, and also a device which fixes the flange of the screw while it is being introduced.

The method permits extra-articular fixation under roentgenographic direction, with proper control of impaction regulated by the surgeon. If the screw is introduced accidentally off center of the head, there is no slipping of the head. No bending of the neck of the femur with subsequent loosening of the screw is possible. In case of pseudarthrosis of the neck, the screw can always be tightened. When consolidation of the neck of the femur is obtained, the screw can be easily removed.—*Emanuel B. Kaplan, M.D., New York, N. Y.*

THE VASCULAR PREREQUISITES OF SUCCESSFUL SKIN GRAFTING. A NEW METHOD FOR THE IMMEDIATE DETERMINATION OF THE ADEQUACY OF CIRCULATION IN ULCERS, SKIN GRAFTS, AND FLAPS. Kurt Lange. *Surgery*, XV, 85, January 1944.

Lange has emphasized what is well known, but perhaps not generally understood, by all men who attempt to repair defects in the surfaces of the body,—namely, the importance of the circulation for the survival of the skin graft. In this article, he has described his method of determining the adequacy of circulation to a given region, and has included the report of some experimental work, which, while not extensive, is perhaps adequate to support his conclusions from clinical experience. He has used the fluorescein test and believes that by this method he is able to ascertain immediately the adequacy of the circulation in the skin flap as well as in the wound or ulcer. Some evidences of direct capillary connection between the wound and the flap, with the pedicle clamped off, were obtained after 144 hours; sufficient vascularization to maintain viability of the flap required a minimum time of eight days.—*Edward L. Compere, M.D., Chicago, Illinois.*

REPAIR OF THE BURNED HAND. George Warren Pierce, E. H. Klabunde, and D. Emerson. *Surgery*, XV, 153, January 1944.

Pierce, Klabunde, and Emerson have again brought into sharp profile the problem of repair of the burned hand. The intricate mechanism of the hand, from the standpoint of its multiple small joints, muscles, tendons, and nerves, and their interrelationships, requires a covering which is both strong and flexible, as nearly as possible resembling that of the normal skin, in order that the best possible function may be obtained. In this paper, the study has been confined to repair after the acute stage has passed.

Since the hand is most often uncovered and hence unprotected, it is burned more frequently than any other single part of the body, with the possible exception of the face. The tendency to protect the hand by closing it results in more frequent and more severe burns of the dorsum than of the palm.

The authors have emphasized the fact that restoration of function and of appearance of the burned hand demands a most thorough knowledge of the anatomy and physiology of the part. The amount of tissue loss and tissue damage must be carefully determined before planning the repair. The earlier the diagnosis is made and the treatment begun, the better the opportunity of the surgeon for obtaining a good result.

The authors have recommended the injection of 1-per-cent. novocain around the ulnar and radial nerves and arteries at the wrist in an effort to interrupt the vasoconstriction which usually attends burn injuries. They have reported remarkable improvement in warmth and in appearance, and presumably in the actual circulation of the hand, following these injections, which should be carried out twice each week, both before and after the skin-graft operations.—*Edward L. Compere, M.D., Chicago, Illinois.*

THE PLASTIC REPAIR OF SCAR CONTRACTURES. Paul W. Greeley. *Surgery*, XV, 224, February 1944.

In this article, Greeley has described several methods of repair of deformities or defects produced by scar contractures. He has not concerned himself merely with the treatment, but has outlined some of the steps which could be taken in the prevention of scar contractures. Cutaneous defects following third-degree burns should be covered early with properly selected skin grafts, as the best method of preventing severe scar contractures. It is not possible to prevent contractures from scars merely by traction or splinting, unless the offending scar itself is eliminated.

The treatment of healed scar contractures consists first, of the most careful excision of all of the contracting scar tissue, and second, of the filling in of the cutaneous defect. The use of the Z or multiple Z plastic incisions, with rotation of flaps, has been widely and successfully used by Greeley. Case reports are presented, showing the marked disability resulting from scar contractures which limit ranges of motion of extremities or immobilize the head by fixing the chin to the chest, and the successful relief of this condition is described and illustrated. Contractures in growing children should be corrected as soon as possible after they develop. If they are permitted to continue through the growing period, permanent deformities of the bones and joints may result.—*Edward L. Compere, M.D., Chicago, Illinois.*

THE TREATMENT OF INTERTROCHANTERIC FRACTURES OF THE FEMUR. Walter G. Stuck. *Surgery*, XV, 275, February 1944.

In this article Stuck has emphasized the importance of intertrochanteric fractures. The statement has been made by many surgeons that the intertrochanteric fracture will always unite and hence is of much less clinical importance than a transcervical fracture. Stuck has expressed the opinion, on the contrary, that, because intertrochanteric fractures occur usually in older patients, they are followed by a higher death rate than that which is caused by intracapsular fractures of the neck. This article contains a brief review of the literature with a discussion of the classification of trochanteric fractures.

Most of the different methods of immobilization and treatment of these fractures have been described or discussed by Stuck. He concludes that internal fixation of trochanteric fractures offers patients greater comfort, less disability, shorter hospitalization, and less likelihood of severe cystic complications from the enforced bed rest. For his own purposes he has selected the Jewett or Neufeld angle nail, the Smith-Petersen nail, two Vitallium screws, or the Smith-Petersen nail with plate.—*Edward L. Compere, M.D., Chicago, Illinois.*

THE TREATMENT OF WAR FRACTURES OF THE FEMUR. Serge S. Yudin. *Surgery, Gynecology and Obstetrics*, LXXVIII, 1, January 1944.

In a concise report, the author has arrived at what he considers the most definitive way of handling fractures of the femur in war surgery. He states that a well-performed operation, followed by intensive local and general sulfonamide therapy and concluded by a closed plaster-of-Paris cast, is, without any doubt, the best existing method for the treatment of compound fractures, including those of the femur. The operative procedure is as follows:

1. Wide excision is made of all injured and contused tissues, regardless of the presence and degree of infection.
2. No drains of any kind are used.
3. Continuous free drainage of the wound is obtained by means of a large counter-opening.
4. The edges of the skin are sutured to the deep fascia with catgut, thus turning the wound inside out by the elastic traction of the skin.
5. During all the stages of the operation, a rich abundant washing of all parts of the wound is carried out with a soap solution.
6. A mixture of sulfanilamide and sulfathiazole in the parts of three-to-one is used in these areas.
7. A closed, non-padded, plaster-of-Paris cast is applied.

For expeditious handling, the author has applied what he calls the "conveyor" method, consisting of one surgeon with eight aides, working simultaneously on three tables. Under his system, this unit is able to handle twenty-five to thirty severely wounded patients, with fractures of the thigh, during a sixteen-hour work day.

He presents a statistical study of 500 cases, treated during the German offensive on Moscow in 1941 and

during two great battles around Rjev in 1942. The mortality rate was 5.4 per cent., of which 2.9 per cent. succumbed to sepsis, 1.6 per cent. from secondary hemorrhage, 0.3 per cent. each from general intoxication, tetanus, and accident. There were no deaths from gas gangrene. In 12 per cent. of the cases received, amputation was performed. Amputation was done immediately in 6.6 per cent., because of lesion of large vessels, gas gangrene, or too extensive injuries with severe infection; and secondarily in 5.4 per cent., mainly because of a generalized septic condition.

The author makes a special point of listing the indications necessitating cast removal for wound inspection. When the rules are adhered to, the patients will withstand evacuation in excellent condition, and half of them will recover from their wounds with complete consolidation of their fractures in the first plaster cast.—*Carroll B. Larson, M.D., Boston, Massachusetts.*

DIVISION OF THE FLEXOR TENDONS WITHIN THE DIGITAL SHEATH. Sumner L. Koch. *Surgery, Gynecology and Obstetrics*, LXXVIII, 9, January 1944.

In spite of the pessimistic attitude sometimes expressed concerning the possibility of successful repair of flexor tendons divided within the digital sheath, good results can be secured, if conditions are favorable, and if the surgeon is willing to use sufficient time and patience. The conditions essential for success are:

1. Fingers with an adequate blood supply and free from excessive scar-tissue formation.
2. Sufficient tendon with a smooth uninjured synovial covering.
3. A retentive mechanism to hold the tendon in contact with the volar surface of the finger when tension is put upon it.
4. Normal mobility at the interphalangeal and metacarpophalangeal joints.

The author elaborates on each of these points, stressing the following: It is hopeless to expect free movement, if both tendon surface and tendon sheath are injured. At least one-half of the normal gliding mechanism which nature has provided must be present, if free movement is to result. The advice sometimes given the surgeon to anchor a divided tendon to the surrounding tissues, so as to prevent retraction and facilitate subsequent repair, is ill-conceived, because it leads to dense scar formation. A tendon which has retracted into the palm may be brought distalward through an intact sheath. If the available tendon is irreparably damaged, one must provide a tendon graft, which is preferably taken from the sublimis tendon or the long extensor tendons on the dorsum of the foot. If a retentive mechanism is necessary, a new annular ligament is formed by passing a slip of normal tendon around the finger and suturing the ends at a point away from the gliding mechanism. At all times it is important to preserve all of the fibrous tendon sheath possible.

For the details of tendon suture, reformation of the fibrous sheath, closure of the finger incision, suture of the proximal end of the graft to the proximal segment of the tendon, the reader is referred to the original article.

Early active movement is not necessary to prevent adhesions. The hands are immobilized in optimum flexion for six to seven days. The dressing is left undisturbed during this period. Active movement, without permitting relaxation of the flexed finger and hand, is begun at the end of the third week. Some support is provided in a partially relaxed position until the end of the fifth or sixth week.

The author reports forty-one cases of secondary repair, of which a tendon graft was necessary in twenty-seven. Primary union took place in all but three cases.—*Carroll B. Larson, M.D., Boston, Massachusetts.*

GANGRENE COMPLICATING FRACTURES ABOUT THE KNEE. Joseph M. King and Bruce J. Brewer. *Surgery, Gynecology and Obstetrics*, LXXVIII, 29, January 1944.

The authors found, in reviewing the literature from 1850 to 1941, inclusive, that forty-seven cases of gangrene following fractures about the knee had been reported. They added four cases which had come under their direct treatment during the preceding twelve months.

Certain factors which tended to enhance the occurrence of vascular complications in fractures about the knee were demonstrated by anatomical dissection,—namely, the proximity of the artery to the bone, and the fact that the artery is restrained or "locked in place" by the muscles and fascia. Either of these factors allows the artery to be easily traumatized, or even lacerated, by jagged fragments, or minimum displacement of fragments. It was emphasized that it is essential to make an early differential diagnosis between a laceration and a thrombosis of the main artery. This can be made from the clinical picture, usually within a few hours. In the presence of a laceration of the main artery, early exploration is imperative to prevent a sequence of events that may result in death to the patient. The therapy instituted for a thrombosis of the main vessel is not early surgery. Rather, the therapy should be directed toward the support of the ischaemic tissue by enhancing the collateral circulation. The latter can be accomplished by immediate alignment of the fragments and immobilization, plus relief of the vasomotor spasm in the obliterated segment, which almost invariably occurs. Chemical lumbar sympathectomy with novocain should be performed as soon as diagnosis is made, and should be repeated as often thereafter as the clinical response indicates. In the early stages of occlusion, the collateral circulation may be enhanced by a moderate application of heat. If the

circulation is not restored to normal or nearly normal at that time, then the extremity should be treated as anaemic tissue and the metabolism should be retarded by refrigeration. Finally, in those cases in which therapy fails to re-establish an adequate circulation, amputation should be performed as soon as there is a definite line of demarcation between the normal and gangrenous tissue.—*Carroll B. Larson, M.D., Boston, Massachusetts.*

Fresh Fractures of the Carpal Scaphoid. Benjamin Obletz. *Surgery, Gynecology and Obstetrics*, LXXVIII, 83, January 1944.

This report is based on a study of forty-five consecutive fractures of the carpal scaphoid in an infantry training camp. During the same period, only ten typical Colles's fractures occurred. This was explained by the fact that the jarring impact of injury did not hyperextend the wrist, because it was rigidly fixed by the soldier's strong forearm muscles. This impact cracked the scaphoid bone at its mechanically weak point, the waist.

In an anatomical study, 13 per cent. of the carpal scaphoids had no arterial foramina proximal to the waist. On the basis of the variations in blood supply, the forty-five fractured scaphoids were divided into two groups: Type I,—fractures without interruption of blood supply to either fragment; Type II,—fractures with interruption of the blood supply to the proximal fragment. Thirty-seven cases fell into Type I and eight into Type II. This classification was made possible by serial roentgenograms taken three to four weeks apart. In Type-II cases, the roentgenograms at the end of three or four weeks showed generalized decalcification in all of the bones except the proximal fragment of the fractured scaphoid. At sixteen to twenty weeks, the densities of the two fragments seemed to blend and the fracture line was obliterated. In the early weeks, the proximal fragment retained its normal calcium, because of a temporary avascularity, which should not be confused with aseptic necrosis, as the latter would appear in the roentgenogram as an irregular mottled density with partial collapse. The clinical importance of this differentiation is to maintain immobilization long enough to allow revascularization of the proximal fragment. In Type-I cases, eight and three-tenths weeks was the average time required for healing, as opposed to nineteen weeks for Type-II fractures.

Continuous immobilization in a plaster-of-Paris gauntlet, as described by Soto-Hall and Haldeman, was the most satisfactory method of treatment, and resulted in complete union in all of the cases where follow-up was available.—*Carroll B. Larson, M.D., Boston, Massachusetts.*

Causes of Pain in Feet after Prolonged Immersion in Cold Water. James C. White and Shields Warren. *War Medicine*, V, 6, January 1944.

Immersion foot has been a subject of much discussion since the first few weeks after the entry of the United States into the present World War. White and Warren state that the most common complaint made by survivors of torpedoed vessels, who have been submitted to prolonged immersion of their legs and feet in cold water, is pain in the areas which have been submerged. The pain begins as soon as the feet have been warmed after rescue, and the benumbing effect of cold has been dissipated.

The authors believe that they have established the fact that there are two different factors which account for this painful syndrome. In the early phase of inflammation, pain is due to anoxia of the injured superficial tissues and nerve endings. It has been found that pain of this type can be controlled by cooling the legs, as this lowers cellular metabolism and makes the reduced demand for oxygen commensurate with the limited supply which can be furnished by the thrombosed superficial blood vessels. The second type of pain is characterized by aching and rigidity of the toes and comes on later, after several days have elapsed following rescue. This may cause prolonged disability. Microscopic studies of specimens from this type of foot have shown an increase in interstitial connective tissue and collagen. This involves blood vessels, muscle fibers and nerves, and is a condition which is most resistant to treatment; six to eight months may be required for sufficient recovery to relieve the more disabling symptoms.—*Edward L. Compere, M.D., Chicago, Illinois.*

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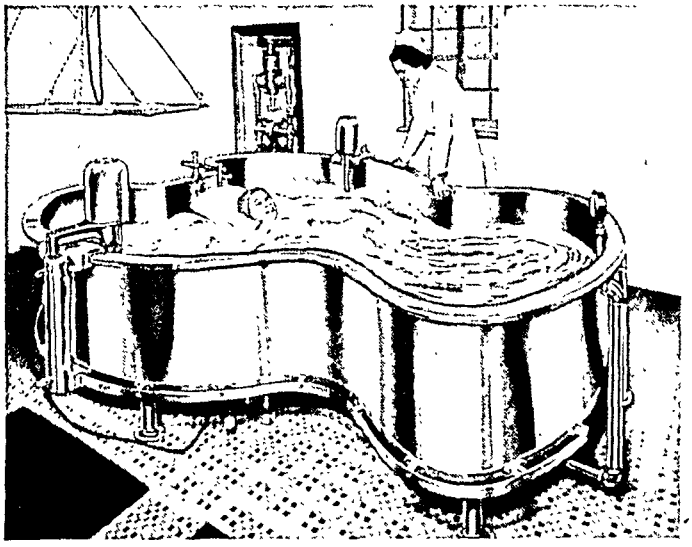

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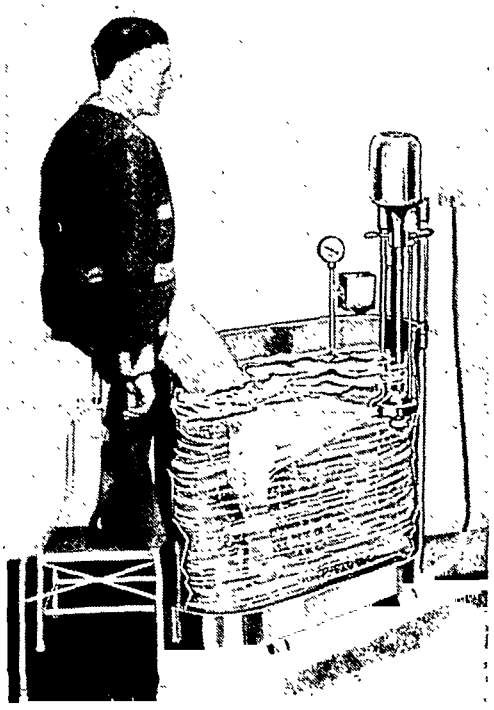

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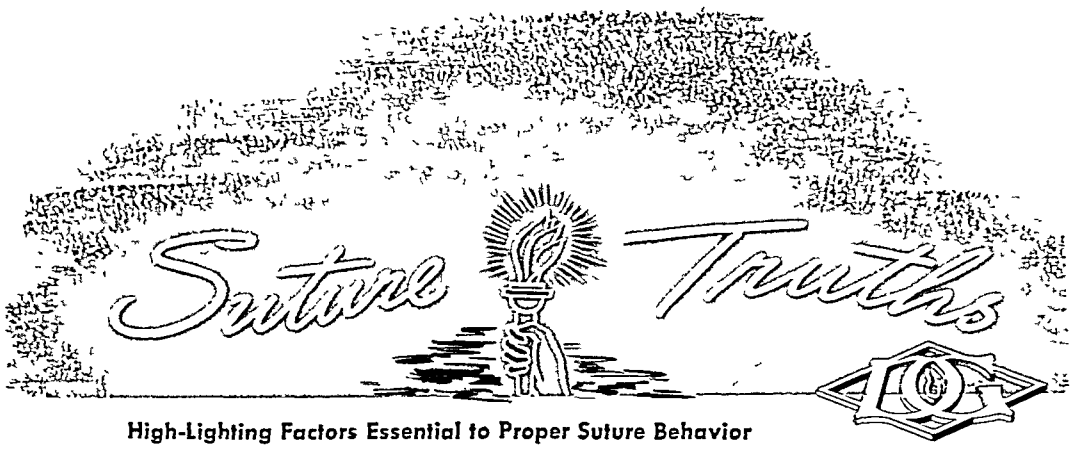


High-Lighting Factors Essential to Proper Suture Behavior

Catgut chromicized *after* the suture is fabricated, provides:

1. maximal strength during early stages of healing

2. uniform absorption periods for all sizes

There are two basically different methods employed for the chrome tanning of catgut. In one, the strips of gut are pre-tanned before being manufactured into the finished strand. In the other, the strand is fabricated first and then subjected to the chrome tanning process.

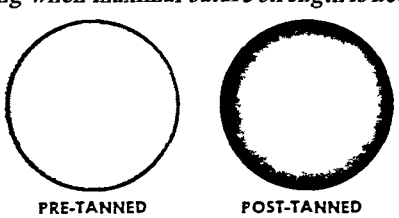
In the pre-tanning method, the various sizes of sutures are made up of similarly tanned material. Therefore, their absorption VARIES according to the diameter of the strand. This means that large size sutures may remain too long in the tissues and small sizes absorb too quickly.

The D & G post-tanning process perfected through more than a third of a century of research and extensive clinical evidence, eliminates this defect in behavior by providing individual treatment of each size. Under this method the finest size is the most thoroughly tanned, the next larger slightly less, and so on—each to the exact degree required to insure proper absorption. Since the process is applied to completed strands of known diameter, it can be controlled with great accuracy to produce sutures of predictable behavior regardless of size.

Another shortcoming of sutures produced from pre-tanned gut derives from the fact that the outer surface is no more thoroughly tanned than the center. Since absorption takes place in proportion to the area exposed to tissue fluids, this means that such sutures lose strength most rapidly in the early stages of healing when the wound is weakest.

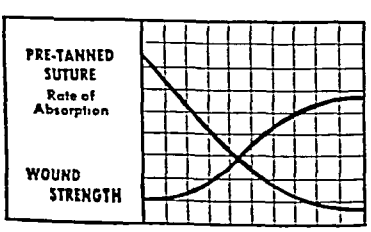
This is exactly opposite to the proper function of a suture which is to RETAIN its maximal strength during the early stages of healing, and then to disappear rapidly as the wound gains strength.

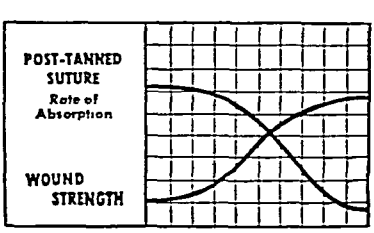
Under the D & G post-tanning method, the outer surface of the strand is tanned to a greater degree than the center. This protects the outer surface from absorption and preserves the original size and strength of the suture during early healing when maximal suture strength is needed.



PRE-TANNED POST-TANNED

By the time the outside of the post-tanned suture is absorbed, healing will be well under way and prompt absorption of the suture desirable.





The curves demonstrate how the pre-tanned suture loses strength rapidly in early stages of wound-healing, whereas the post-tanned suture retains maximal strength during this period when strength is most needed.

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